AMD RYZEN 5 2600
Reviewed: Zen+ gets the mainstream treatment PG. 74

49-INCH SUPERWIDE
Get your eyes ready for next-level visuals PG. 80

YOUR ULTIMATE SERVER
Build your perfect ad-blocking, streaming, backup box PG. 36

MAXIMUM PC

MINIMUM BS • AUGUST 2018 • www.maximumpc.com

SPEED UP WINDOWS

- Make your machine run like new again
- Solve all of your OS problems
- Clean out the junk for faster booting

STEP-BY-STEP GUIDE
Build this awesome LED PC PG. 68

VIDEO ENCODING 101
Improve quality and keep your bandwidth down PG. 46

FUTURE

CORSAIR

THESE AREN'T JUST HEADSETS, THEY'RE YOUR LIFELINE

UP TO 16 HOURS OF GAMEPLAY ON A SINGLE CHARGE

Compatible with: PC and PlayStation 4*
*7.1 surround sound only available on PC

CUE

DISCORD

/CORSAIR

FIND OUT MORE AT **CORSAIR.COM**

ORIGIN PC 101: The Best Supplies For Victory Royale

EVO15-S

ORIGIN PC Laptops are Powered by Intel Core 8th Gen Processors, Up to an Intel Core i7 8700k 6-Core Processor

PC GAMER EDITOR'S CHOICE ★★★★★

MAXIMUM PC KICK ASS!

intel CORE i7 8th Gen

Powered by Intel® Core™ i7 Processors

FREE Lifetime 24/7 Service & Support
Online Financing Available

© 2018 ORIGIN PC Corporation. All rights reserved. ORIGIN "O" Symbols are trademarks of ORIGIN PC Corporation. All other trademarks are property of their respective owners. Intel, the Intel logo, Intel Inside, Intel Core are trademarks of Intel Corporation or its subsidiaries in the U.S. and/or other countries.

Back to School Specials Now available at ORIGINPC.com

MILLENNIUM

- Custom HD UV Printing
- Aluminum Chassis with Steel Frame
- Patented ORIGIN PC Variable Mounting Technology
- Toolless Upgradeability
- Aluminum or Tempered Glass Side Panels

Custom High-Performance Desktops

- Award-Winning Custom Desktops and Laptops
- Professionally Hand-Built With Quality Name-Brand Components
- Over 100 Point Quality Checklist Signed by a Dedicated Team of Professionals
- All Systems Include Free 24/7 & 365 Lifetime US-Based Tech Support
- Combined Experience of Over 30 Years of PC Manufacturing and Support

NEURON CHRONOS

ORIGINPC.COM @originpc

EPIC GAMES

NVIDIA GEFORCE GTX GAME READY

ORIGIN HIGH-PERFORMANCE PCS

© 2018, Epic Games, Inc. Epic, Epic Games, the Epic Games logo, Fortnite, the Fortnite logo, Unreal, Unreal Engine 4 and UE4 are trademarks or registered trademarks of Epic Games, Inc. in the United States of America and elsewhere. All rights reserved. NVIDIA, the NVIDIA logo, the GeForce GTX logo, GeForce, NVIDIA GameWorks are registered trademarks and/or trademarks of NVIDIA Corporation in the United States and other countries.

SUBSCRIBE TODAY!
see PG. 42

inside

AUGUST 2018

26 SPEED UP WINDOWS

26 SPEED UP WINDOWS
Give your PC a burst of speed with this collection of tools to tweak, optimize, and reinstall Windows.

36 BUILD THE ULTIMATE SERVER
Discover how you can use enterprise-level technology to make your home network extra awesome.

46 VIDEO ENCODING DEEP DIVE
Next-generation video encoders deliver better quality with smaller files; get up to speed now.

IN THE LAB

76 GIGABYTE X470 AORUS GAMING 7 WI-FI

83 KINGSTON KC1000 HHHL 960GB

89 CORSAIR HS70 SE WIRELESS

91 THRONES OF BRITANNIA: A TOTAL WAR SAGA

QUICKSTART

12 THE NEWS
AMD goes 32-core, Intel hits 28 at 5GHz; anything legal allowed on Steam; Facebook in hot water again.

20 THE LIST
The top seven cases to come out of Computex 2018.

Our Core i3-8350K machine passes the aesthetics test with flying colors.

R&D

56 AUTOPSY
Seven steps to seeing whether the OnePlus 6's days are numbered.

58 HOW TO
Emulate the Atari ST on your Pi; securely delete data with Eraser; manage a project using Trello; design an esports team logo.

68 BUILD IT
How we constructed our Phanteks-powered Core i3-8350K RGB rig.

LETTERS

24 DOCTOR

94 COMMENTS

OWN THE BLU-RAY™ 7/24

AND THE DIGITAL MOVIE NOW

READYPLAYERONE

#READYPLAYERONE

SCAN TO SEE MORE!

© 2018 WARNER BROS. ENT. ALL RIGHTS RESERVED.

AVAILABLE ON 4K, BLU-RAY™, DVD & ON DIGITAL NOW

SCAN TO SEE MORE!

RampageTheMovie

#RampageMovie

© 2018 WARNER BROS. ENT. ALL RIGHTS RESERVED.

OWN

BLACK LIGHTNING: THE COMPLETE FIRST SEASON

ON DIGITAL, BLU-RAY™ AND DVD TODAY!

BLACK LIGHTNING TM & © DC COMICS. © 2017 WBEI

SAGER

GAMING NOTEBOOKS

SAGER RECOMMENDS WINDOWS

BLAZING PERFORMANCE

NP9877 NOTEBOOK

$2,899

FREE UPS GROUND SHIPPING*

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8700K Processor
- 17.3" Full HD, 144Hz Matte Display with G-SYNC
- Opt. 17.3" 4K QFHD Matte Display with G-SYNC
- NVIDIA® GeForce™ GTX 1080 8GB GPU
- Opt. Dual NVIDIA® GeForce™ GTX 1080 GPUs
- 16GB DDR4-2400MHz Memory
- 250GB Samsung 970 EVO NVMe M.2 SSD + 1TB 7200RPM HDD
- Full Color Programmable Backlight Keyboard
- Killer Wireless-AC 1535 + Bluetooth

$2,399

NP9175 NOTEBOOK FREE UPS GROUND SHIPPING*

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8700K Processor
- 17.3" Full HD, 144Hz Matte Display with G-SYNC
- Opt. 17.3" 4K QFHD Matte Display with G-SYNC
- NVIDIA® GeForce™ GTX 1070 8GB GPU
- Opt. NVIDIA® GeForce™ GTX 1060 or 1080 GPU
- 16GB DDR4-2400MHz Memory
- 250GB Samsung 970 EVO NVMe M.2 SSD + 1TB 7200RPM HDD
- Full Color Programmable Backlight Keyboard
- Killer Wireless-AC 1535 + Bluetooth

$1,999

NP9155 NOTEBOOK FREE UPS GROUND SHIPPING*

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8700K Processor
- 15.6" Full HD 144Hz Matte Display with G-SYNC
- NVIDIA® GeForce™ GTX 1060 6GB GPU
- Opt. NVIDIA® GeForce™ GTX 1070 or 1080 GPU
- 16GB DDR4-2400MHz Memory
- 250GB WD Blue M.2 SSD + 1TB 7200RPM HDD
- Full Color Programmable Backlight Keyboard
- Killer Wireless-AC 1535 + Bluetooth

All Sager systems come with one year Limited Warranty & Lifetime Tech Support. Prices and specifications are subject to change without notice or obligation. Sager Corporate Offices 18005 Cortney Court, City of Industry, California 91748 ©2018 by Midern Computer, Inc. All rights reserved. Intel, the Intel Logo, Intel Inside, Intel Core, and Core Inside are trademarks of Intel Corporation or its subsidiaries in the U.S. and/or other countries. All company and/or product names mentioned herein are trademarks and/or registered trademarks of their respective companies. *Free UPS Ground Shipping valid to contiguous US order only.

Windows 10

intel CORE i7 8th Gen

NP8375 NOTEBOOK FREE UPS GROUND SHIPPING*

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8750H Processor
- 17.3" Full HD 144Hz Matte Display with G-SYNC
- NVIDIA® GeForce™ GTX 1070 8GB GPU
- Opt. GeForce™ GTX 1060 6GB GPU (NP8373)
- 16GB DDR4-2666MHz Memory
- 250GB Samsung 970 EVO NVMe M.2 SSD + 1TB 7200RPM HDD
- Per-Key RGB Backlight Keyboard
- Intel® Dual Band Wireless-AC 9560 M.2 AC + BT
- Slim design with only 0.98 inches thin

NP8955 NOTEBOOK FREE UPS GROUND SHIPPING*

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8750H Processor
- 15.6" Full HD 144Hz 5ms IPS Matte Display
- NVIDIA® GeForce™ GTX 1070 8GB GPU with Max-Q
- Opt. GeForce™ GTX 1060 6GB GPU (NP8953)
- 16GB DDR4-2666MHz Memory
- 250GB Samsung 970 EVO NVMe M.2 SSD + 1TB 7200RPM HDD
- Full Color Programmable Backlight Keyboard
- Intel® Dual Band Wireless-AC 9560 M.2 AC + BT
- Ultra-slim design with only 0.73 inches thin

NP8954 NOTEBOOK After $200 Instant Savings!

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8750H Processor
- 15.6" Full HD 120Hz 3ms 94% NTSC Matte Display
- NVIDIA® GeForce™ GTX 1070 8GB GPU with Max-Q
- 16GB DDR4-2666MHz Memory
- 120GB WD Green M.2 SSD + 1TB 7200RPM HDD
- Full Color Programmable Backlight Keyboard
- Intel® Dual Band Wireless-AC 9560 M.2 AC +BT
- Ultra-slim design with only 0.73 inches thin

NP7851 NOTEBOOK After $100 Instant Savings!

- **Windows 10 Home**
- 8th Generation Intel® Core™ i7-8750H Processor
- 15.6" Full HD 144Hz 5ms IPS Matte Display
- Opt. 17.3" Full HD 144Hz Matte Display (NP7871)
- NVIDIA® GeForce™ GTX 1060 6GB GPU
- 16GB DDR4-2666MHz Memory
- 1TB 7200RPM HDD
- Full Color Programmable Backlight Keyboard
- Intel® Dual Band Wireless-AC 9560 M.2 AC + BT

CALL US TOLL FREE: 1.800.669.1624 **CUSTOMIZE & PRICING GO ONLINE: SAGERNOTEBOOK.COM**

Dealer/Var, government and corporate pricing are available. Please call for details.

gamesradar+

One-stop destination for games, movies, TV, and more!

New Channels: Movies, TV and Cool Stuff!

www.gamesradar.com

MAXIMUMPC

EDITORIAL
Executive Editor: Alan Dexter
Deputy Editor: Zak Storey
Senior Editor: Jarred Walton
Hardware Lead: Bo Moore
Contributing Editor: Chris Angelini
Contributing Writers: Alex Campbell, Alex Cox, Nate Drake, Ian Evenden, Jeremy Laird, Chris Lloyd, Neil Mohr, Nick Peers
Copy Editor: Katharine Davies
Editor Emeritus: Andrew Sanchez

ART
Art Editor: Fraser McDermott
Image Manipulation: Gary Stuckey
Photography: Future Photo Studio

BUSINESS
US Marketing & Strategic Partnerships: Stacy Gaines, stacy.gaines@futurenet.com
US Chief Revenue Officer: Luke Edson, luke.edson@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
East Coast Account Director: Victoria Sanders, victoria.sanders@futurenet.com
East Coast Account Director: Melissa Planty, melissa.planty@futurenet.com
East Coast Account Director: Elizabeth Fleischman, elizabeth.fleischman@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Jack McAuliffe, jack.mcauliffe@futurenet.com
Director, Client Services: Tracy Lam, tracy.lam@futurenet.com
Director, Retail Sales: Bill Shewey, bill.shewey@futurenet.com

PRODUCTION
Head of Production UK & US: Mark Constance
Production Controller: Vivienne Calvert
Project Manager: Clare Scott
Production Assistant: Emily Wood

FUTURE US, INC.
11 Hanover Square, 14th Floor, New York, NY 10005, USA
www.futureus.com

Global Chief Revenue Officer: Charlie Speight
Vice President, Marketing & Operations: Rhoda Bueno
Finance Director: Ryan Lamvik
HR Generalist: Carla Marcos

SUBSCRIBER CUSTOMER SERVICE
Maximum PC Customer Care,
Future Publishing, PO Box 2024, Langhorne, PA 19047
Website: http://myfavoritemagazines.com
Tel: 844-779-2822
Email: contact@myfavoritemagazines.com

BACK ISSUES
Website: http://myfavoritemagazines.com
Tel: +44 344 848 2852

REPRINTS
Future US, Inc., 11 Hanover Square, 14th Floor, New York, NY 10005, USA
www.futureus.com

Next Issue On Sale August 21, 2018

©2018 Future US, Inc. All rights reserved. No part of this magazine may be used or reproduced without the written permission of Future US, Inc. (owner). All information provided is, as far as Future (owner) is aware, based on information correct at the time of press. Readers are advised to contact manufacturers and retailers directly with regard to products/services referred to in this magazine. We welcome reader submissions, but cannot promise that they will be published or returned to you. By submitting materials to us, you agree to give Future the royalty-free, perpetual, non-exclusive right to publish and reuse your submission in any form, in any and all media, and to use your name and other information in connection with the submission.

FUTURE
Connectors. Creators. Experience Makers.

Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR)
www.futureplc.com

Chief executive **Zillah Byng-Thorne**
Non-executive chairman **Peter Allen**
Chief financial officer **Penny Ladkin-Brand**

Tel +44 (0)1225 442 244

Alan Dexter

TWEAK WINDOWS FOR SPEED AND PROFIT

CHANCES ARE THAT YOU, like us, have spent a bit of cash in the last few years to eke a little more performance out of your machine. A new SSD here, a graphics card there, and maybe even that double whammy of a motherboard and CPU combo that brings your machine bang up to date. If you've had a windfall, you may have also invested in that most expensive of current upgrades, RAM, but regardless of what you've dropped your cash on, the concept is still there: to get a faster, more responsive system.

But what if you can attain a similar performance boost just by tweaking Windows? Cut the rubbish, the stuff you absolutely don't need for your day-to-day operations, and you can see a few percentage point increases in an operation here, a boot time there, and free up resources for the applications that really matter. Such performance boosts may take a little time to find and get right, but they are essentially free, and in tracking them down, you may also find a few nasties lurking in your system that are worth getting rid of.

Windows has improved significantly over the years, and it's no longer the resource-hog that it once was, but there are still things that are worth tweaking and watching out for. This is particularly true if you're trying to get the most from an older machine, or at least one that uses older components. When your budget is tighter, it makes even more sense to spend time getting the most from your operating system, as freeing up your limited resources has the potential to have an even bigger impact on overall performance. Turn to page 26 to see what tweaks are worth spending your time on, as well as seeing whether your best option is simply to reinstall Windows, and if so, how best to do it.

One area where you can improve your day-to-day performance is by offloading some of the work to a home server. Chances are, you have suboptimal ways of sharing files around the home at the moment, perhaps moving files around on USB sticks, instead of simply streaming them around your home. This is where our feature on building your own home server comes in (page 36), as we show you the easy way of getting a full-featured server up and running, with all the software you need to perform an array of tasks.

Our final big feature this issue looks at what the different video formats mean to the quality and file size of your movies: How you're probably not using the best file formats for the future of your media, and also how you'll want to use the latest formats if you're making the transition to 4K and beyond. We explain how encoders work, and what sort of hardware you'll need to decode them. If you deal with video at all, this is an essential read.

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

AMD Goes 32-Core, Intel Hits 28 at 5GHz

AMD and Intel battle for headlines—one true, one fake

COMPUTEX IS the largest IT trade show in Asia. All the big players attend, and it generates a slew of announcements, launches, and headlines, from PC cases that double as fish tanks (no, really), to more serious matters. AMD and Intel always manage to grab the lion's share of coverage, even if they have to be a little inventive in the process.

AMD was there to show the world Threadripper 2, its new high-end desktop chip. Threadripper is essentially multiple Ryzen chips on a single die. The original packs two eight-core Zen chips, but the silicon was neatly quartered, and the EPYC server chips already sport 32 cores. So, we could guess what Threadripper 2 had in store: a full 32 cores and 64 threads on a desktop. Yowsers. It pops into the existing TR4 slot on X399 motherboards. There are some memory bandwidth issues—the extra silicon doesn't have direct memory access—but this shouldn't be too much of problem unless you absolutely thrash the bandwidth. There were two pre-production versions on show: a 24-core and a 32-core. Both the sample chips ran at a base clock of 3GHz, with boost to 3.4GHz. TDP is a touch high for a desktop chip at 250W, although apparently a conservative figure—don't stint on the cooler, though. Threadripper 2 should be in the wild before the end of the summer. Prices are yet to be confirmed, but expect the usual AMD competitiveness. It'll deliver, according to AMD's Jim Anderson, "heavy metal performance."

Meanwhile, Intel made everybody get rather excited when it unveiled a 5GHz 28-core chip, which it said would be on sale in the last quarter of the year. A demonstration rig ripped through a few benchmarks, including a Cinebench R15 score of 7,334. Initially, details were decidedly vague—the word "overclocked" was not mentioned during the stage presentation; later, this was deemed to be "accidental." Predictably enough, the stunt grabbed headlines for a day or so, which was the point.

Intel does have a genuine 5GHz part—the i7-8086K. Just 50,000 available worldwide, at $425. It marks the 40 years since the chip that started it all, the 8086.

Then people calmed down, and started looking a little closer at the rig. It soon dawned that what they had actually witnessed was a piece of industrial-strength overclocking on a server chip. The heart of the system was an LGA-3647 board and a Xeon CPU—probably a carefully selected Xeon-P 8180. Then some sub-ambient liquid cooling was applied, from a huge unit usually used for aquariums. And—hey presto—we have a 5GHz chip. There might well be a new Xeon part coming in the fourth quarter, but it's not for desktops, and it certainly won't run at anything like 5GHz. It was a good bit of showmanship, at least. Or, if we are being less charitable for a moment, it was a desperate last-ditch attempt to undermine AMD's Threadripper 2 announcement.

Intel did announce a 5GHz chip you could own: the Core i7-8086K, a six-core Coffee Lake chip. It's limited edition—50,000 are planned. The i7-8086K is most likely a cherry-picked 8700K with the base speed bumped to 4GHz, and a single-core turbo boost tweaked to the magical 5GHz. The name is a homage to the 8086 from 1978, Intel's first x86 architecture that powered the first PC, 40 years ago. The Core i7-8086 will cost around $425.

In the world of the HEDT, Threadripper gives Intel a headache. It has nothing at the same price that delivers such a punch, and AMD claims to have 40 percent of the gaming market. No doubt Intel has something brewing but, as the main stage stunt demonstrated, it hasn't got anything ready. **–CL**

> "The stunt grabbed world headlines for a day or so, which was the point.

CB CREATIVE BLOQ

> Digital design is like painting, except the paint never dries.

NEVILLE BRODY

The number one destination for
graphic design news, views, and how-tos

creativebloq.com

ANYTHING LEGAL ALLOWED ON STEAM

Apart from trolls, obviously…

A GAME THAT WAS VIEWED by many as the height of bad taste, a simulation of a school shooting, called *Active Shooter,* was pulled from Steam after a week of protests. However, the initial cited reason was not the offensive content, but rather the creator's history of copyright infringement, review manipulation, and customer abuse. Not what we were expecting. This has led to Valve clarifying what it will—and won't—allow on Steam.

The blog post includes this nugget: "We've decided that the right approach is to allow everything on to the Steam Store, except for things that we decide are illegal, or straight-up trolling." And this gem: "The Steam Store is going to contain something that you hate." It then pulled a few titles that, presumably, were straight-up trolling. These included *AIDS Simulator* (not what you might think, but just as bad), *ISIS Simulator,* and *Suicide Simulator.*

Steam is the world's largest PC games distributor, so this is important stuff. It is trying to pitch itself as a conduit, rather than a gatekeeper, as do Google and myriad others. Content is controversial, rather than simply "bad." It's a tough call, and Steam has left its options open with the trolling clause, a suitably wide definition that will enable it to pull anything that draws too much heat, while still espousing free speech.

Valve has fudged the issue somewhat, but it's difficult to know what else to do. It is clearly unwilling to act as judge and jury on all its content; this way it can at least weed out the most troublesome. However, its rather nebulous policy statement has pleased few in the process. And this is without touching on its inconsistent and often prudish view on sexual content (leading to some comical on-screen censorship), which looks as if it has possibilities now—it is legal, after all. **–CL**

FACEBOOK IN HOT WATER YET AGAIN

PRIVATE MESSAGES ARE BROADCAST TO THE WORLD

A "GLITCH" AT FACEBOOK between May 18 and 22 led to 14 million users having their private posts being free for all to view, instead of friends and family. Apparently, Facebook accidentally altered the default privacy settings, but it took until May 27 for it to restore them. This time, the trouble was of Facebook's making. Soon after, the company started firing out alerts to users to check their privacy settings, actually in response to new European legislation, but being sent worldwide. A timely reminder, at least.

Facebook holds huge amounts of data on anybody who's been anywhere near it—a serious responsibility. Five days is too long to fix such a fundamental problem. Any potential fall of Facebook's digital empire could have many causes; one of them is loss of trust. **–CL**

HALF A MILLION INFECTED ROUTERS

VPNFilter

VPNFilter IoT malware gets everywhere

A SOPHISTICATED PIECE of malware, originating from a Russian group of hackers, has quietly found its way into over half a million routers worldwide. It's a botnet that can steal data, deliver malicious payloads, the "man in the middle" attack, and kill infected devices. It communicates via Tor, and survives a reboot. Sounds scary. It's largely been aimed at small and home office routers, and NAS devices. The kind of gear that may not be carefully updated or monitored.

VPNFilter received instructions from metadata hidden in images on Photobucket, or the toknowall.com domain. The Photobucket images have been removed, and the FBI has shut down the backup domain. This still leaves those infected routers out there, though. A hard reset, a return to factory default settings, should clear the infection, although it is advisable to check individual manufacturers' advice. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

FASTEST SUPERCOMPUTER
IBM's Summit machine for the US Department of Energy manages over 200 petaflops, beating the 125 of its Chinese rival.

SERIOUS WATER COOLING
Microsoft dropped a data center of 864 servers into the sea off Scotland to see if cold seawater can save on power.

LAPTOPS GO DUAL-SCREEN
The next big thing in laptops? Computex saw dual screens, with a touch keyboard as required.

TRAGEDIES

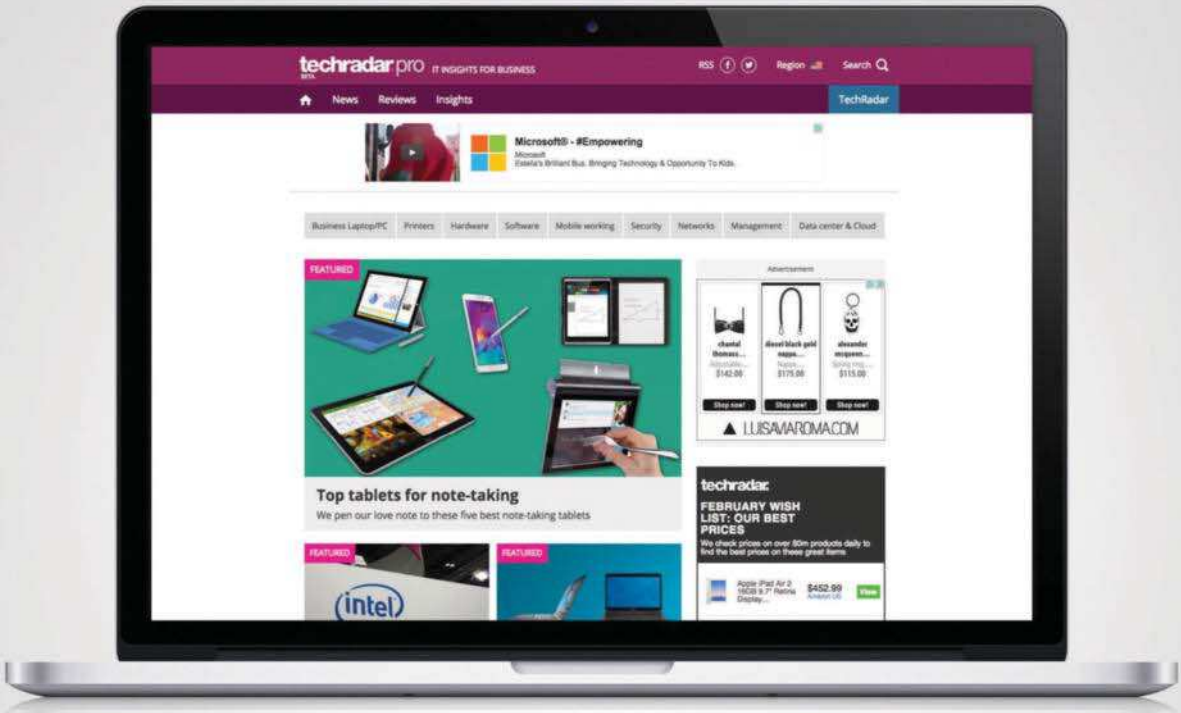
APPLE LEGAL HEADACHE
A class action against Apple has been launched, claiming that all Apple Watches are defective; the screens detach or crack readily.

HUGE FINE FOR GOOGLE?
Falling foul of European anti-trust legislation, Android could be landed with a fine of billions.

DNA PROFILES STOLEN
DNA tester MyHeritage has had 92 million account details stolen; DNA profiles are increasingly saleable on the black market.

techradar.pro

IT INSIGHTS FOR BUSINESS



Best practices and solutions

Up-to-the minute news

In-depth reviews

http://www.techradar.com/pro

XBOX
THE OFFICIAL MAGAZINE

ISSUE 215 JULY 2018
WWW.GAMESRADAR.COM/OXM
XBOX
MAGAZINE
INDIE REVOLUTION
THE ID@XBOX GAMES YOU SHOULD BE EXCITED ABOUT THIS YEAR!
EXCLUSIVE STUDIO ACCESS!
SHADOW OF THE TOMB RAIDER
THE END OF LARA'S ORIGIN STORY PLAYTESTED INSIDE
Eidos Montreal talks jungle combat
Xbox One X hands-on
First look at Lara's cataclysmic mistake
NEW INFO!
ELDER SCROLLS
We explore Summerset and talk to the TESO team
HUGE NEW DETAILS!
NO MAN'S SKY
Exploring the intergalactic adventure on Xbox One
FINAL VERDICT!
HELLBLADE
Can the Xbox One X elevate this stunningly animated title?

The essential magazine for all things Xbox

NEW ISSUE ON SALE NOW

ORDER DIRECT FROM MYFAVOURITEMAGAZINES.CO.UK/GAMING

Jarred Walton

TECH TALK

Dealing With Data Caps and Proxy Caches

THIS PAST MONTH, I did something I've never managed before: I went over the 1TB data allowance that comes with my Internet service. There was no fee—this time—but my data use has been on an upward track for decades, and it's only a matter of time before 1TB becomes stifling.

My Internet speeds increased from 20Mb/s to 300Mb/s over the past 15 years. In that same period, PC games moved from CDs and DVDs to digital downloads, and 2–6GB installs to 50GB and more. Video drivers can update several times a month, at 400MB a pop. Cut the cable TV and move to streaming video, and that can be hundreds of GB every month, with 4K streams using even more. Don't forget to back up all your data in the cloud, which in my case happens over a paltry 12Mb/s upstream connection.

I've never liked the idea of data caps, and looking at smartphones only reinforces how bad it can get. 4G/LTE can download at speeds of several hundred Mb/s, but most "unlimited" plans throttle your speed after 22GB per month of data. You could exceed that in just over 30 minutes. It's not that you'd normally chew through that much data on a smartphone, but the telecoms love this sort of pricing model, and would be happy to apply it to high-speed Internet connections. And in the post-net neutrality world, paying more for my Internet seems inevitable.

With multiple PCs for testing purposes, each grabbing the same game patches and Windows 10 updates, it can add up to hundreds of GB per month. Not content to sit back and watch the data usage continue to climb, I took matters into my own hands, and set up a reverse proxy cache. I put together a PC with a 1TB SSD cache, and looked for solutions.

There are a few problems, like the fact that most web traffic is now HTTPS (SSL encrypted), so a proxy can't do anything to cache frequently accessed web pages. Even for non-encrypted files, content delivery networks (CDNs) mean you could get the same file from multiple sources. Thankfully, smart people have done a lot a lot to address such problems, and Steamcache, Steam-Squid, Lancache, and other open-source projects reduce the amount of work.

I ended up running Debian Linux with Lancache installed. It almost worked. Or rather, it almost worked without a bunch of additional futzing about, and now several days later it mostly works. My main problem is my ISP, which runs its own Steam proxy cache. That wouldn't be so bad, except it uses SSL encryption (unlike Steam's normal CDNs), so my own proxy would get directed to the ISP proxy, open an SSL connection, and not cache any of the resulting files. The solution was to block my system from seeing the ISP proxies, but that's not a perfect solution—Steam downloads happen at about 50–100Mb/s, for example. At least Origin, UPlay, Blizzard, and several other gaming platforms work fine, along with Microsoft's Windows Update servers.

Still, I find it grating that my ISP wants to limit its external data use by running a Steam proxy cache, yet in doing so it interferes with my own attempts to do the same thing. Even more irritating is the data cap in the first place. Yes, I'm in the top 1 percent of data users,

> I could blow through my entire data allowance in one working day of eight hours.

Are routine data cap overcharges the future of our post-net neutrality Internet?

I'm sure of that. Maybe I should be charged extra... except I'm already paying $30 per month for a faster Internet connection. I can choose from Internet speeds of 15Mb/s to 400Mb/s, but all of those include the same 1TB data cap. You could theoretically download 1TB in about a week with a 15Mb/s connection, while the 60Mb/s connection would only take a day and a half. My 300Mb/s connection? I could blow through my entire data allowance in one working day of eight hours.

There's no truly unlimited 1Gb/s connection in my area. There's only one other ISP as well, except it's a DSL provider with speeds that top out at 40Mb/s. Ending net neutrality is not going to help people like me who are stuck with a single provider.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

MAKE YOUR OWN PROJECTS WITH THE RASPBERRY PI

Learn the electronics, computing and coding skills you need to make your own projects with the Raspberry Pi, and let your imagination run wild

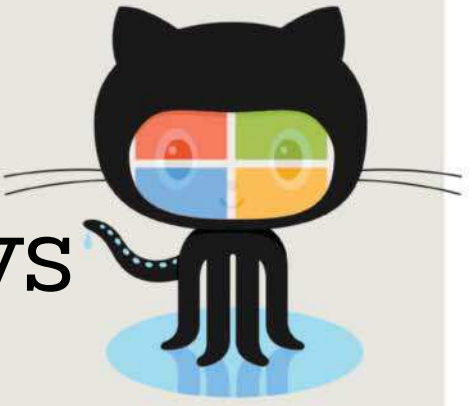
Ordering is easy. Go online at:

www.myfavouritemagazines.com

Or get it from selected supermarkets, newsagents or bookstores

Alex Campbell

OPEN SOURCE



When the Fox Buys the Henhouse, Should Hens Worry?

I'M NOT SO SURE HOW I feel about Microsoft's acquisition of GitHub yet. Anytime the corporation interacts with the open-source community, emotions can run high—and with good reason.

If you've never used Git before, here's a refresher: Git is what's known as a version control system, which has largely supplanted other systems, such as Subversion (SVN) or the Concurrent Versioning System (CVS). It tracks changes in directories and text files through a system of commits. If you've ever used Track Changes in Word, or looked at the version history of a document in Google Docs, it's a similar concept. The power behind Git is that it is relatively easy to clone a repository of text files (usually code), and attribute changes to specific users.

It is important to note that GitHub is not Git itself. Git can be set up on remote servers to host repositories that users can pull or clone from, and push changes to. GitHub is a service that provides easy administration of Git repositories through a web interface. GitHub is free to use, so long as your repositories are publicly available. If you want to have private repositories, you have to pay.

GitHub's business model hadn't been so profitable of late, which contributed to the acquisition deal. (The company was also without a CEO.) Microsoft isn't one to pass up on a good acquisition—see Skype and Minecraft—thus the new ownership.

There's value in this acquisition: GitHub is a great resource for deploying applications to cloud platforms. By hosting code on GitHub, it becomes really easy to deploy code across any number of servers quickly, and without needing the code on the machine you're working from. It's easy to see a tighter integration of Azure and GitHub in the future.

> Mention of open source or Linux and Microsoft in the same sentence is worthy of a degree of suspicion.

For those of us old enough to remember when Steve Ballmer was CEO of Microsoft, mention of open source or Linux and Microsoft in the same sentence is worthy of a degree of suspicion. After all, he's the guy who called Linux (and open source) a "cancer." He made Linux and open source the enemy of the Microsoft ecosystem.

Ballmer's fiery rhetoric was a cause of militancy in the open-source world in the 2000s. Microsoft and Windows were seen as a threat to open-source and free software. Software offerings aside, Microsoft was the Great Satan to the open-source community; no good could ever come from the company.

Fast-forward to today, and Microsoft looks a lot different. With Satya Nadella at the helm, Microsoft has been far less hostile to open source. The Windows Subsystem for Linux allows users to work in an Ubuntu, OpenSUSE, or even Kali Linux environment on a Windows machine. Azure, Microsoft's cloud platform, embraces Linux. Even Microsoft's SQL Server is available for Linux, and Microsoft's Visual Studio Code and PowerShell applications are open source.

That said, there is still some uneasiness about the acquisition. And there's good reason: The old foe of the open-source world just bought the warehouse where a lot of open-source code is stored. Regardless of the relative benevolence of Nadella's vision, some question whether they want Microsoft as the new landlord of their Git repos. GitHub competitor GitLab saw a 10 percent uptick in project migrations from GitHub in the days after the announcement.

For end users, the consequences of the announcement are unclear. In the short term, I'm inclined to believe there will be little functional impact on the end user. For those distributions that regularly rely on upstream repositories to distribute source code (such as the Arch Linux AUR), the impact may simply be new upstream source URLs.

But now that the fox is landlord of the henhouse, one has to wonder whether the hens will get spooked. I plan on leaving my couple repositories up on GitHub for the time being. But I'm not ecstatic about suddenly having to keep a wary eye on a service I assumed was generally trustworthy before.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

TOP 7 CASES TO COME OUT OF COMPUTEX 2018

7 THERMALTAKE LEVEL 20

A reimagining of a classic, Thermaltake reinvigorates its masterfully crafted compartmentalized behemoth for 2018.

6 ASUS TUF GT501

Taking inspiration from five-year-old cases, this TUF/In Win mix comes with roof straps for easy transport, and a $150 price tag.

5 ANTEC PROJECT X

The Project X is an outlandish new step for Antec. Still in the concept stage, it throws out some wild ATX angles.

4 PHANTEKS EVOLV X

The evolution of Phanteks's legendary Evolv chassis packs a ton of improvements for a meager $10 price increase.

3 COOLER MASTER COSMOS C700M

A smaller mid-tower version of the C700P. Thanks to its facelift and smaller form factor, it looks set to be a top seller.

2 IN WIN 307

The 307 has 144 addressable RGB LED squares in the front panel, and comes with a $300 price tag.

1 IN WIN Z TOWER

More art piece than chassis, this monstrous sculpture costs $5,000 and weighs an impressive 90lb.

MAKE THE SWITCH FROM WINDOWS TO THE MOST POPULAR LINUX DISTRIBUTION AROUND!

Discover the best features of Ubuntu's default software, the best FOSS apps for you to download from the Software Centre, and then go beyond the Unity interface.

ON SALE NOW

FUTURE

Ordering is easy. Go online at:

www.myfavouritemagazines.com

Or get it from selected supermarkets, newsagents, or bookstores

TALKING

BY ZAK STOREY

A Modder's Insight Into the World of Custom PCs

Alphacool's Dave Alcock discusses the industry, modding, and where the future will take us

How far do you go when customizing your rig? What's the limit? Are you willing to beat a chassis into submission to improve airflow, or get that snazzy lighting you want just right? We speak to Dave Alcock, Alphacool's marketing honcho and modder extraordinaire to get to grips with the custom mod scene, and take a look at where the industry is heading.

Dave Alcock, Alphacool's US modding and PR marketing rep.

Maximum PC: Tell us a little bit about yourself. What got you into modding? When did you start doing it? And how did you end up where you are today?

Dave Alcock: Hi! My name is Dave Alcock, better known on the Internet and in the modding world as davido_labido. I'm a 29 years young guy from the UK, who went from playing *BF2* competitively to modding to working for a rather large liquid cooling company. This is going to be a long bit of text, so sit down, grab a coffee, and enjoy!

It all started when I was 15, competing at a massive LAN event. I showed up with the rest of the team, and saw an awesome liquid-cooled rig. Instantly, I wanted one. I didn't know why, I didn't have a use for it, and I didn't understand how it worked, I just knew I needed it. Fast-forward to when I was 23, again at a gaming event, and I saw another liquid-cooled build. This time I had the cash (well, I was old enough for a credit card), and I started to investigate it all. Luckily, I had a friend at a PC hardware eseller who just so happened to manage its liquid cooling section. He talked me through all the parts I needed, and had it shipped to me. I started to look at it all like it was adult Lego, but I didn't have a clue what to do. I threw it all together to get the system running, and that was it. A few months later, I had another event to attend, and was embarrassed about how much of a mess my system was, so I started to change it, and make it pretty. This is when I figured out other ways to make it look good and perform better. I chopped up the case, sprayed parts, and generally just did what I wanted. At the next event, a company came up to me, and offered me free parts to redo the build bigger and better. I agreed, and XSPC started me in the world of sponsorship. I gained a huge list of sponsors. Whilst modding, I had a real job—I was an engineer for DHL, but also worked for review sites eTeknix and TechPowerUp. Eventually, I quit DHL to run the modding section for Bit-Tech. I was sent to Aquatuning to write an article on its new offices. Whilst there, I was offered an opportunity I couldn't turn down: to work for Alphacool as a marketing rep. As Alphacool was one of my sponsors, they knew me, I knew them, and it made sense. I'm now the marketing rep for Alphacool in the UK and US, and I'm still modding, which is awesome.

MPC: Case modding has a very niche competitive scene—a lot of our readers won't even know it exists—so can you tell us what's involved in a competition, like some of the ones in Taipei and Computex?

DA: The way I usually describe case modding to those who have never seen it is to say: "It's like what car enthusiasts do to cars, but to computers." We change the colors and chassis, upgrade parts, chop things up, and generally try to make something that's different and unique. The next question we get asked is: "What's in it for the companies that sponsor you, and why do they hold events?" Well, modders help move the industry forward, particularly in the design area. For instance, vertical GPUs are seen more and more often now—modders have been doing this for years. In my Pandora's Purple Box build, I put a GPU on a 45-degree slant. I wasn't the first to do this, but the more modders who did it, the more it was seen, and the more requests companies received for a similar idea. When I did it, so many people asked how it worked, it was crazy. Now it's everywhere.

As for events, more and more companies are doing these now. I attended one in 2016 in Taiwan called In Win Mod in Taiwan. Daniel "B-negative" Harper was invited to attend from the UK, and he needed a teammate. He chose me, and we flew to Taiwan to compete against some of the world's best modders. It was an amazing experience, and we won one of the categories. The reason companies do this is simple: Our builds get seen hundreds of thousands of times, and that means their products are, too. It's marketing for companies,

and they also get ideas for cases. It's a fantastic co-operation, and it's great to see that most of the large companies are helping modding move forward.

MPC: When it comes to building your own machines, when do you stop? Are you ever satisfied?

DA: It depends. Sometimes I just throw something together and leave it at that. I often need something that isn't too crazy, so I know I can swap parts out easily without destroying how it looks. I often just work on a test bench.

On the other hand, I keep all the mods that I build for events and shows, and I do use these, too. Often I see little changes months after I have "finished," and come up with a new idea. Mods are never finished.

MPC: Moving on to the industry as a whole—and liquid cooling in particular—where do you see it going?

DA: The liquid cooling industry has grown immensely, even in the relatively short time I've been part of it; it has pushed forward with more people using liquid cooling. It wasn't so long ago that AIO units weren't available, and although these aren't really considered liquid cooling, they're a very good first step. Alphacool has many AIO options that are expandable with pre-filled parts, so you can expand the loop without worrying about a custom loop. I think this is one area companies will try to push, to get people who are worried about custom loops taking the first steps. Once you use one of the expandable AIO units, you can see how similar they are to a full loop, but we make it easier with quick disconnects.

MPC: What are your thoughts on the current RGB phenomenon?

DA: I'm not a big fan of the RGB craze when it's set to one of the crazy lighting modes. However, I do like it overall, as it gives the user more control over their system aesthetics. Not so long ago, if you wanted a certain color for a motherboard, you had to buy a certain brand and board. For example, I wanted an orange build a while back, so I had to buy the Gigabyte Z77X-UP7. It was the only board I liked that had the orange I wanted. Now, I can buy any RGB board, and change the LED colors. It is the same with any other product; it can be changed to suit your own preferences. I'm currently doing a build with Cooler Master, called UniKAOrn Farts, which will be full RGB. I want to go over the top with this, and make it as headache-inducing as possible.

MPC: What is it about a custom loop that makes them so much more worthwhile than an AIO?

DA: Again, it is more about being able to customize everything you want to do. Most traditional AIO units lock you into their parts; you have no way to fix them, and no way to swap parts out. Alphacool has changed this, so you can modify most of the parts in the AIO, but you're limited by the power of the pump or the size of the radiator. As you can expand our AIO units, you can add these extra parts, but then you're basically doing a custom loop. I find it far better to dive straight into a custom loop, so I can choose exactly what I want for the perfect balance of aesthetics and performance. I can choose different colors, radiator sizes, fittings, and balance everything out—it's great!

MPC: What do you think makes Alphacool so different compared to other companies, such as EKWB and Primochill?

A 45-degree angled GPU, anyone?

DA: I've used a lot of products from most of the liquid cooling brands. EKWB was a big sponsor of mine, and I like the products it offers. In all honesty, I don't focus on what we do differently from our competitors, as there are plenty of customers for us all, and I think it would be far better to work with other companies than compete against them. Having said that, it is my job to market our products, and we garner a lot of praise for using copper for the majority of our parts. We do have some aluminum end caps on reservoirs, and even some stainless steel panels on our special radiators, but everything that touches fluid is copper, brass, or nickel-plated copper. This means compatibility across our range is ensured, and you are receiving high-quality materials. Also, everything we make is done by us; we have our own factories, design team, and warehouses. This enables us to create products that other companies would have to outsource. We even make products for other companies as an OEM!

MPC: What tips can you give people who are looking to get into modding?

DA: Just jump in and give it a go. Don't worry about what others think, or if the hardware isn't the best—just start modding. You can pick up old cases for free quite easily, and they're perfect to practice on; you don't need to spend a fortune at the start. Oh, and never do it with the aim of being sponsored for "free parts." There's no such thing as free parts—sure, I haven't paid cash for components for years, but I've worked crazy hard to get builds out the door in a few days, or I have spent crazy money on tools, materials, and travel to do the things I love. It isn't free.

MPC: What is it about the industry that you love the most?

DA: The people. It sounds corny, but I'm motivated by my friends in the industry. Even you *[Zak]*. We met via Facebook and a modded build I did a few years ago. We only met recently, but we've chatted multiple times, and when we did meet, it was like meeting an old friend. Competitors are friends with each other, we all go to the same parties and events, and as we spend a lot of time with each other, we become better friends than with "real-life" friends. If I need anything, a post on social media, and all the industry rallies behind you.

MPC: Any other thoughts?

DA: I'd just like to say that you don't have to be the best modder in the world to do well. My builds are quite mediocre, but I've done well in a short period of time, mainly because I like to try things out, and I show everything I do, even if it fails. If there's one thing you take from this interview, just give it a go, talk to other modders, and see where it takes you.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Cleaning Up
> Spectre-Proofing
> Upside-Down ATX

Using Disk Cleanup

Hey, Doc. It's been years since I've written in. I have a question about an old utility that comes from previous versions of Windows. In the Administrator command prompt under Windows 10 version 1803, what are your recommended settings for the following Disk Cleanup commands: "cleanmgr /sageset:*" after which I run "cleanmgr /sagerun:*"?

I know that a number between 1 and 99 replaces the * in both commands.

–Keith Brooks

THE DOCTOR RESPONDS: The value replacing * can actually be anything from 0 to 65535. By specifying different numbers, you can create lots of preset combinations. This comes in useful for automating clean-up across large networks.

There are 24 different items to choose between after typing in the first command and launching the Disk Cleanup Settings pane. Check the ones corresponding to files you'd like to get rid of. If you aren't sure whether to pick a particular option, click it for a brief description of what it comprises. Afterward, typing "cleanmgr.exe /sagerun:*" (with your original value replacing the asterisk) starts the clean-up process with your selected options.

Spectre Protection

Doc, this is one that I'm sure is going to impact a lot of us, so if you have a resolution, you'll make a lot of folks happy.

I built my system in 2012. Back then, it was my dream machine. It started with an Asus P8Z68V-PRO/GEN3 motherboard, an Intel Core i7-3770K CPU, 8GB of Crucial Ballistix DDR3-1866 memory, a 128GB Crucial SSD, a Cooler Master 750W PSU, and a GeForce GTX 680. Over the years, I upgraded to a 1TB Samsung 850 EVO, 16GB of DDR3 memory, and a GeForce GTX 1080 Ti. The system is still rock solid and very fast, but apparently, I have to scrap it in order to remain secure.

Of course, I'm referring to the Spectre hardware vulnerability. Microsoft's patches don't address Spectre. They only help with Meltdown. Only a firmware update will resolve Spectre, I'm told. The problem is that Asus doesn't have a BIOS update for its P8Z68V that includes the Intel microcode patch. When I contacted Asus about this, it responded that the P8Z68V is end-of-life, and there won't be a BIOS update to resolve the security issue. Digging around on Intel's site, the company says you have to get the update through your hardware vendor.

Is there any way to resolve the Spectre issue at this point for folks in my position? I'd rather not scrap a PC that still performs well. I've run the InSpectre utility from Steve Gibson, and it shows that I'm protected from Meltdown but not from Spectre. **–B.J. Koho**

THE DOCTOR RESPONDS: The Doc was recently in your exact position with a Core i7-3770K of his own, along with an Asus motherboard condemned to never receive another BIOS update. But don't rush to trash your system. Microsoft recently released an optional patch that includes the necessary microcode to protect against Spectre Variant 2.

In theory, loading the microcode via Windows isn't ideal. After all, upgrading to a future build of the OS could wipe out your protection, as it recently did for many folks who installed version 1803 and found a previously installed Spectre mitigation wiped out. But for anyone in your situation, Microsoft's solution is the only way to patch against the vulnerability. Search for "KB4100347" in Microsoft's Update Catalog (www.catalog.update.microsoft.com) for a download link.

The Doc did confirm that his Core i7-3770K was Spectre-protected after upgrading to Windows 10 Pro 1803 and KB4100347 using InSpectre.

Inverted ATX Cases

Hey Doc, I'm a case-on-the-desk kind of guy. I enjoy appreciating what I built (who doesn't?), and I want to keep all of that nasty debris on the floor where it belongs. I cried a little the last time I cleaned out my wife's PC on the floor, which looked like a poor excuse for a vacuum cleaner.

I am rocking a nice new system based on a Ryzen 5, a Radeon RX Vega 56, DDR4-3200 memory, a PCIe NVMe SSD plus four hard drives in RAID, and an older NZXT case. The problem, as I see it, is that the PC sits on the left-hand side of my desk, with its window facing the wall instead of me. I'd rather not rearrange my life to move the case. So, are there any cases that'd give a visually stimulated patron of the PC arts a window on the opposite side? Or are all cases windowed on the left side only? **–Brad Lowery**

↘ submit your questions to: doctor@maximumpc.com

THE DOCTOR RESPONDS: If you think about the way a motherboard is laid out, moving it to the opposite wall of your case wouldn't work in the same orientation. But there are cases that support an inverted ATX configuration, with the mobo flipped upside down, and the CPU under your add-in cards. Others accommodate smaller microATX motherboards sitting horizontally.

Corsair's Carbide 600C, for example, is a reasonably priced chassis designed for inverse installations. Because it's purpose-built, the three bundled fans inside are already set up for optimal airflow. Be Quiet!'s Dark Base Pro 900 costs quite a bit more, but adds modularity. This allows you to move the motherboard tray to support larger form factors, flip it around entirely, move hard drive bays, and create room for custom cooling loops. The Thermaltake Core V21 is more cube-shaped, enabling vertical or horizontal placement. You can even stack two on top of each other to create room for elaborate water-cooling or storage setups. BitFenix, Cooler Master, Rajintek, and SilverStone have their own options as well.

USB Problems

Dear Doc, I have been trying to exorcise a demon that has plagued me for at least six months. That is, my USB ports mostly work. For all the simple devices, they seem to function fine. But for my Corsair K95 keyboard and Logitech mice, the problem rears its ugly head. The keyboard starts fine, and I can input my PIN using the number pad. After that, the pad is useless unless I only want to move the cursor around.

I have addressed all of the issues reported by Kaspersky Total Security, I've removed and reloaded the latest USB drivers, and I even installed a separate USB card. Nothing helps. My thinking is that the problem is with the Gigabyte Z170X-Gaming 7 motherboard.

I've been working on computers since the early '80s, but this one eludes me. I have not wiped and reinstalled Windows, because I have a ton of software installed, and it makes me physically ill to think about reconfiguring all of it. Please help!

–Leland Litchfield

THE DOCTOR RESPONDS: It's tempting to blame the issue on your motherboard's USB ports, except that you mentioned the problem persists with your peripherals plugged into an add-in card. Regardless, the Doc would start by making sure you have the latest BIOS for your Z170X-Gaming 7 motherboard (a new version was published earlier this year). Also, grab the latest Thunderbolt 3 controller driver from Intel's website—the one on Gigabyte's support page is incredibly old.

Assuming those aren't the root of your issue, though, and that you've already tried moving your devices around to ports corresponding to your motherboard's other controllers, you could always disable the Windows 10 fast startup feature to see if it might be related. In Windows Settings, click "System," then choose "Power & sleep" from the left-hand pane. Click "Additional power settings," then "Choose what the power buttons do." Next, choose to "Change settings that are currently unavailable" and deselect "Turn on fast startup (recommended)." This should force Windows to initialize all drivers when it starts up.

Backing It Up

Dear Doctor, we recently bought a new MacBook for our CEO. We were upgrading his old Mac to a new one, and instead of copying files over and reconfiguring all of his settings, I used Time Machine to create an image of the old system. Then, I restored that image to the new one.

It took a while to complete the process, but I preferred that method, and it was frankly pretty easy to do. I was wondering if you have a good recommendation for a Time Machine alternative that's compatible with Windows. I Googled some options and found RollBack, Genie Timeline, CrashPlan, and Backblaze. **–Javier Monarrez**

An inverted ATX layout makes Corsair's Carbide 600C ideal for windows on the right-hand side.

THE DOCTOR RESPONDS: It sounds as though you're already familiar with some of the most popular options. RollBack RX Home is free to use, though it only gives you seven snapshots. Genie Timeline costs $40. Both of those options are designed to be used locally. CrashPlan for Home no longer offers new subscriptions; instead, the company suggests moving to its Small Business product for $10 per month. It gives you the option of creating local and online backups with no capacity limit. Backblaze involves a subscription as well ($5 per month), and it's cloud-based.

Alternately, Windows 10 includes functionality that you may find sufficient—and at no additional cost. If you open up Windows Settings, then click "Update & Security," you'll see "Backup" on the left pane. Selecting that brings up an option to "Automatically back up my files," which is off by default. Turn it on, then click "More options" underneath the toggle. The backup is configured to run every hour, and maintain those saved files forever. Windows gives you a list of protected folders, which you can add to. Or, simply use exclusions if you want to start by backing up complete drives or directory structures.

Should you ever need to restore an old file, type "File history" in the Windows 10 search bar to bring up "Restore your files with File History." There, the user interface lets you to step backward and forward in time to find a file that was deleted, or pick out an older version you might have mistakenly saved over.

The same Backup pane in Windows Settings also has an option called "Go to Backup and Restore (Windows 7)," which is used to create an image of Windows 10 itself. Clicking this takes you to another window labeled "Back up or restore your files." If you've never used the feature before, click "Set up backup," pick a destination, decide if you want Windows to configure the backup or choose what to save manually, then create a schedule for updating the image.

Between the File History and Backup and Restore options, it's easy to get a lot of powerful protection up and running from within Windows.

Recycle Bin
JetBoost v2.0.0
Boost your PC!
A click on the Boost button gives you the ultimate working, gaming, and surfing online experience!
Boost
Customize
Type here to search
NVIDIA G-SYNC HDR

SPEED UP

Give your PC a burst of speed with this collection of tools to tweak, optimize, and reinstall Windows By Maximum PC Staff

WINDOWS

When it comes to outright speed, your PC never seems to have enough. Or to put it another way, it doesn't matter how smoothly it's running, your PC could always do with being that bit faster. Armed with the right know-how, you can fine-tune your PC to squeeze more performance from it, but the effort involved can be more than it's worth.

Which is where we come in. In this feature, we've dug out the finest free tools we know of that can help speed up your machine. We kick things off by revealing our favorite tools for fine-tuning your system. Your hardware could use some optimization, too, so we've collected the best overclocking and tuning apps for pushing it beyond its limits. And finally, when you next bite the bullet and reinstall Windows, we reveal five tools that can help safeguard and speed up the process, before running you through the steps you need to take to restore Windows to its pristine, like-new form, unencumbered by bloated apps and collected detritus.

Your computer is ready to take its performance to the next level with the help of our essential apps, so turn the page to get started with giving it a much-needed boost of speed.

TUNE UP YOUR SYSTEM

Discover how to streamline your PC for an extra burst of speed with the help of these powerful—and free—apps

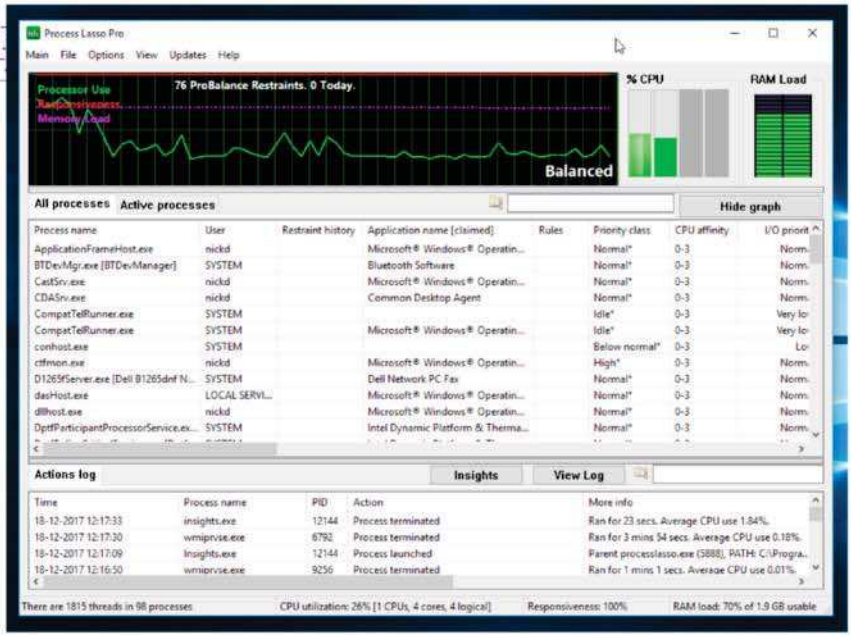
Windows has been designed for maximum compatibility, so while it runs on a wide range of PCs, it's not been optimized for any of them. This is where the apps in this part of the feature come into play. They give you the tools required to speed up your PC in several ways. As is usually the case with apps, less is more—there's no point recommending 100 apps whose combined demands outweigh the benefits of using them in the first place, which is why we've pared them down to five.

You'll find our favorite tool for managing startup, enabling you to both monitor and improve the way Windows loads. If you're frequently blighted by lockups, then Process Lasso can keep those runaway programs in check. There's also a safe tool for tweaking low-level Services to free up more system resources, JetBoost for temporarily halting unnecessary processes when running games or other demanding applications, and a handy defrag tool to build upon Windows' own.

PROCESS LASSO

IF YOUR MACHINE frequently appears to stop responding or grinds to a halt momentarily, the culprit is usually a program or system process that's making excessive demands on your system to the detriment of the other running programs and processes, including Windows itself.

This problem is more acute on older or lower-powered PCs with 2GB of RAM or less, where there's less memory to go around. Process Lasso (https://bitsum.com) monitors your PC's processes, and when it detects one making runaway demands, it temporarily lowers its priority, to ensure your PC keeps running smoothly. The free version includes all the core functionality, or upgrade for more features: A lifetime single-user license for the Pro version costs $36; Home Pro ($46) covers every PC in your home.

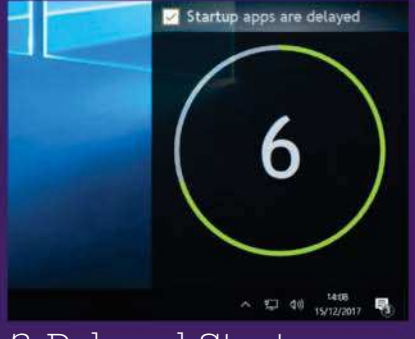


MONITOR AND IMPROVE WINDOWS STARTUP

BootRacer (www.greatis.com/bootracer) has become our go-to app for managing startup. Not only does it enable you to see which programs are launching with Windows, but it times everything, too, enabling you to keep an eye on the boot process, and giving you a heads-up should some resource-sapping program suddenly insert itself into the startup process. Here's a quick rundown of its key features.

1. Time Your Start

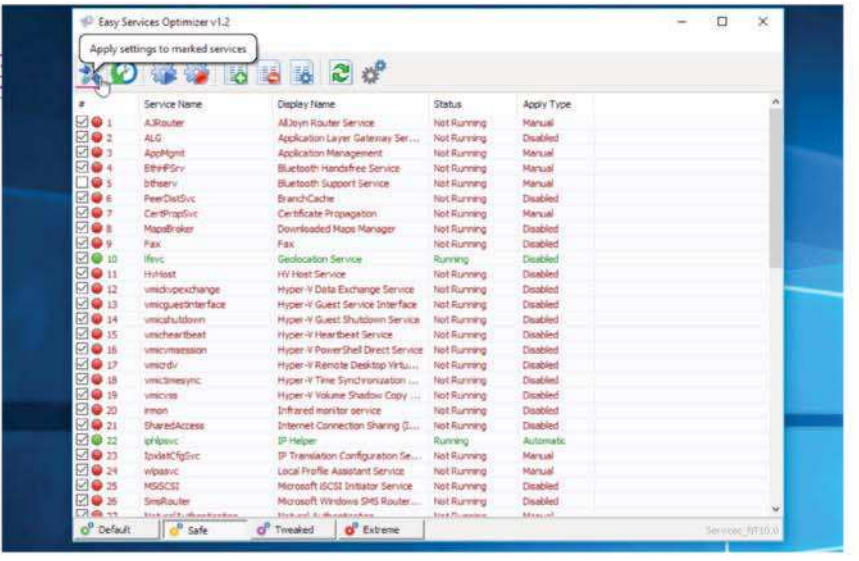
The first thing BootRacer does is measure your start time, from the moment your PC is switched on until your startup apps finish loading. This helps you identify bottlenecks at different points of the process, so you can target your troubleshooting.



2. Delayed Start

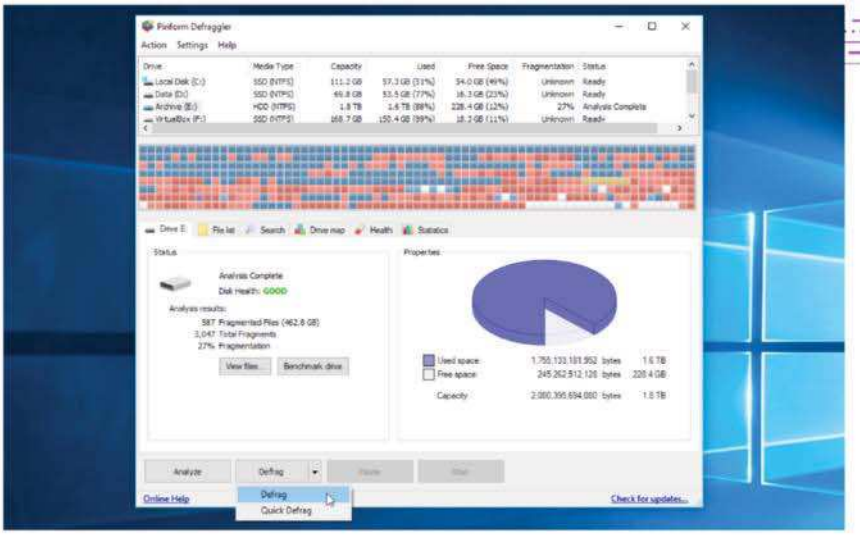
BootRacer also inserts a delay of 10 seconds to the startup process, to give Windows a chance to finishing loading before any startup programs are launched. This helps stop your PC being overwhelmed by demands for system resources.

EASY SERVICE OPTIMIZER



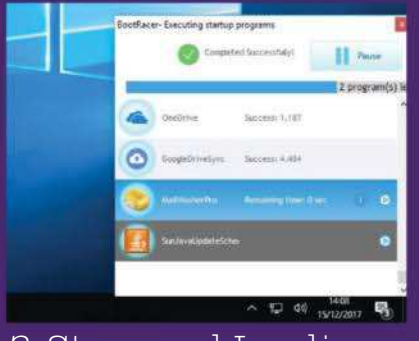
SERVICES ARE SPECIAL low-level programs that run in the background, performing numerous functions. Each one uses its share of system resources and—armed with the right know-how—you can selectively disable them to free up memory and processor time. But why do it by hand when Easy Service Optimizer (www.sordum.org/8637) can do the hard work for you?

The program provides three presets: Safe, Tweaked, and Extreme. For most people, Safe is best—it's a "no-risk" option, and you can easily revert to Default if things stop working. Advanced users can go further, and the app enables you to manually tweak individual Services, too.



DEFRAGGLER

IF YOU'RE STILL RUNNING Windows off a traditional platter-based hard drive, keeping it defragged is a must. Windows' own Disk Defragmenter does a good enough job, particularly in Windows 10, but if you want to squeeze even more performance out of your drive, Defraggler (www.piriform.com) is the tool to turn to. Not only can you opt to move large files to the end of the drive to help speed up performance, but Defraggler enables you to defrag individual files and folders, too—perfect for quickly defragging a single file without tying up your PC for hours. Defraggler also offers an "Optimize" option for SSDs, which manually wipes space marked for deletion to boost drive performance.



3. Staggered Loading

BootRacer also loads programs in sequence, one after the other—again, to balance the demands on your PC. Click the three-line "hamburger" button to reveal a list of all the programs that are loading, along with their respective startup times.

4. Manage Apps

Click "Startup Control" from the main program to manage startup programs. You can disable or delete them from here, and rearrange their running order—for example, to get your faster-loading programs launched first.

JETBOOST

JETBOOST (www.bluesprig.com/jetboost.html) is a tool that quickly shuts down unnecessary services and programs on a temporary basis only. For example, if you play demanding games or encode HD video, JetBoost can deliver a speed boost for the duration, then restore everything for normal operation after—all via its one-click button. Also handy for silencing intrusive apps and notifications while you work.

OVERCLOCK YOUR PC

Push your PC's components to their limits and deliver noticeable speed improvements with these hardware-tuning apps

While there's no substitute for hardware upgrades to deliver the ultimate performance fillip, the fact remains that it's highly likely that various components within your machine aren't being pushed to their absolute limits. By default, many components are configured in a conservative fashion, but if you're armed with the right tools, you can start squeezing them that little bit further.

It's worth noting that overclocking your processor, RAM, and graphics can shorten the lifespan of those components, particularly if their core temperature rises. Thankfully, our recommended tools have built-in fail-safes and monitoring mechanisms, so you can check your tweaks aren't going to bring your PC to its knees.

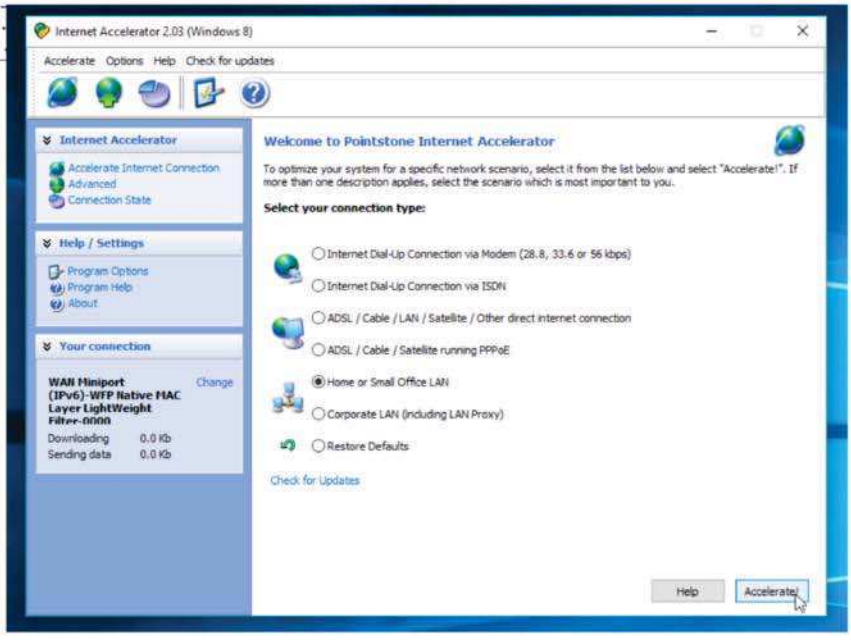
You can also speed up other hardware areas—without introducing undue stress. Expect to deliver minor speed bumps to your SSDs and Internet connection, and make sure you update your drivers, to ensure the latest, fastest ones are in place.

INTERNET ACCELERATOR 2

THIS FREE TOOL, which you can download from www.pointstone.com/products/InternetAccelerator, works best on older machines running Windows 7 or earlier. It's designed to make it incredibly easy to tweak various Windows settings relating to your network connection, which can have a positive effect on various Internet-related activities.

Using Internet Accelerator 2 can't physically increase the speed of your connection, of course, but it can optimize your settings to make full use of the bandwidth you have available. It ensures your downloads, web browsing, and so on are going as fast as they're able.

To use it, first select your setup type (home or small office LAN for most people), then simply click "Accelerate!" to see whether you can speed things up.

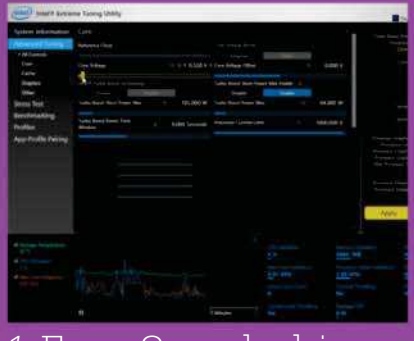

Internet Accelerator 2.03 (Windows 8)
Accelerate Options Help Check for updates
Internet Accelerator
Accelerate Internet Connection
Advanced
Connection State
Help / Settings
Program Options
Program Help
About
Your connection
WAN Miniport (IPv6)-WFP Native MAC Layer LightWeight Filter-0000
Change
Downloading 0.0 Kb
Sending data 0.0 Kb
Welcome to Pointstone Internet Accelerator
To optimize your system for a specific network scenario, select it from the list below and select "Accelerate!". If more than one description applies, select the scenario which is most important to you.
Select your connection type:
Internet Dial-Up Connection via Modem (28.8, 33.6 or 56 kbps)
Internet Dial-Up Connection via ISDN
ADSL / Cable / LAN / Satellite / Other direct internet connection
ADSL / Cable / Satellite running PPPoE
Home or Small Office LAN
Corporate LAN (including LAN Proxy)
Restore Defaults
Check for Updates
Help
Accelerate!

MOTHERBOARD TOOLS

IF YOU SELF-BUILT your PC, or know its motherboard make and model (find it with CPU-Z at www.cpuid.com), visit the manufacturer's website, where you may find tools for tuning or overclocking. Examples include A-Tuning (ASRock), AI Suite 3 (Asus), and OC Genie (MSI). You'll also find the latest drivers here.

BOOST YOUR CPU SPEED THE EASY WAY

One way you can speed things up is by overclocking your processor, so both it and your RAM run faster than they were designed to. There are dangers with this approach—overheating can shorten your components' lives—but official tools help to minimize the danger. AMD users should install AMD Overdrive (www.amd.com/overdrive); Intel users should download and install the Extreme Tuning Utility (https://intel.ly/2y3DBw6).



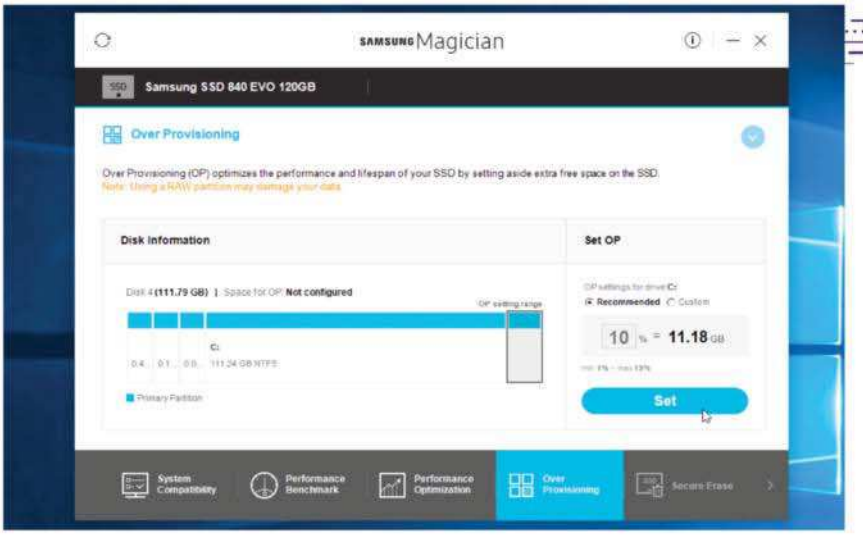
1. Easy Overclocking

Your overclocking options with Intel's utility vary according to the particular processor you have—some are incredibly limited, while others offer more scope. If supported, the utility can also enable you to overclock the onboard graphics.

MSI AFTERBURNER

OVERCLOCKING your graphics card won't turn it into the latest model, obviously, but it can improve its performance, to make barely playable games run that bit more smoothly. If your PC comes with an AMD or Nvidia graphics chip, MSI Afterburner (www.msi.com/page/afterburner) has your back.

It works by enabling you to tweak your chip's clock frequency and voltage, while also giving you control over any onboard fans to help to try to minimize the temperature increase. Better still, there are real-time monitors to show you the effects of your overclock, too. Remember—you risk damaging your graphics card by overclocking, so use with care.

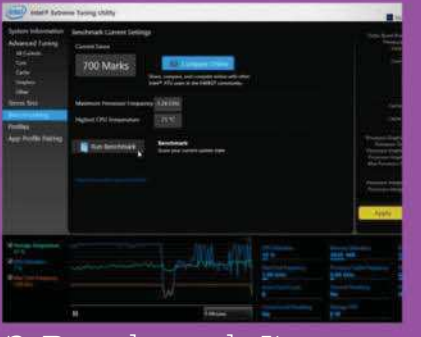


SOLID-STATE DRIVE (SSD) UTILITIES

IS YOUR SSD DRIVE running at its maximum? Be sure to visit your drive manufacturer to download and install any software tools. These alert you to health issues, provide firmware updates, and may offer settings to tweak performance. For example, Samsung Magician (http://bit.ly/2CUTUt7) offers a Rapid Mode switch, and Over Provisioning, which reserves space on your SSD to aid performance and lengthen lifespan. Similar tools can be found for OCZ (http://bit.ly/2DnDgU4), SanDisk (https://bit.ly/2y4Hr88), and Crucial (https://bit.ly/2JEi7au), among others.

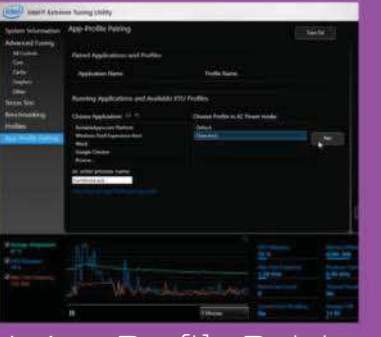
2. Test Your Overclock

After tweaking your settings (visit http://bit.ly/pcgoclock for a detailed guide to what to do), select "Stress Test" to perform a five-minute stress test across processor, memory, and/or graphics, depending on what you choose to overclock.



3. Benchmark It

Select "Benchmarking" to run a quick series of benchmarks to see the effects of your overclocking—benchmark before you start the process, and perform three benchmarks at a time, taking an average to give you a more accurate result.



4. App-Profile Pairing

Go to "Advanced Tuning" and click "Save" to create a profile of your overclocked settings. Pair it with an app under "App-Profile Pairing," so your PC is only overclocked when needed—for example, when playing games or editing 4K video.

REINSTALL TOOLS

Ensure your next Windows reinstall goes without a hitch with the help of these essential tools and utilities

When you next come to reinstall Windows, it pays to take precautions in the form of various backups—File History is essential for personal data, but what about program settings, and how about a fail-safe backup in the event of a botched reinstall?

The reinstall process is also a good excuse to make changes to the way you organize data on your PC's main internal and external drives, while you'll also want to make sure that you have the latest versions of the Windows installation files, to save you a lengthy post-install update process.

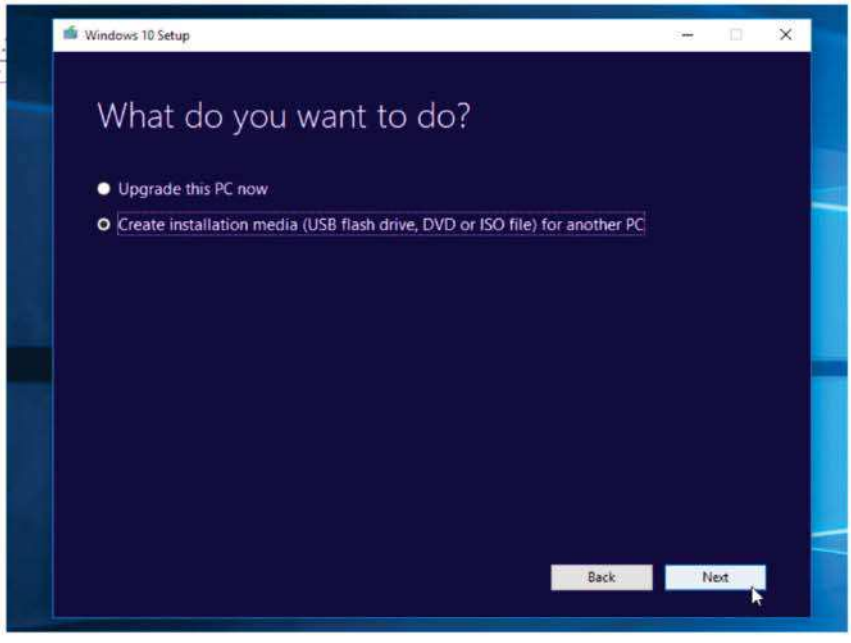
All these potential problems are covered by our favorite reinstall tools. You'll find the best drive backup tool in the business rubs shoulders with our free partition editor of choice and the Windows Media Creation Tool, which ensures you have the latest version of Windows 8.1 or 10 on your PC.

Throw in a couple of other handy applications we've tracked down for you, and your next Windows reinstall just got a whole lot simpler (never mind safer).

WINDOWS MEDIA CREATION TOOL

THE DAYS OF RELYING on an increasingly out-of-date installation disc are long gone. Simply download the Windows Media Creation Tool for Windows 8.1 (www.microsoft.com/software-download/windows8) or Windows 10 (www.microsoft.com/software-download/windows10), and it will walk you through the process of creating your reinstall media, either on DVD or a USB flash drive.

Better still, the Windows Media Creation Tool also downloads the latest installation files first, which means that if you reinstall Windows 10, for example, you get it with the Fall Creators Update already applied. Always create fresh media prior to reinstalling Windows, to ensure you have the latest version of the operating system.


Windows 10 Setup
What do you want to do?
Upgrade this PC now
Create installation media (USB flash drive, DVD or ISO file) for another PC
Back
Next

TAKE A BACKUP WITH MACRIUM REFLECT FREE

Reinstalling Windows from scratch is a one-way process. Once you've formatted the drive and reinstalled Windows, everything you once had is gone. What happens if you forget a key file or setting, or the reinstall process goes wrong, and you want to roll things back? Don't worry—Macrium Reflect Free (www.macrium.com/reflectfree.aspx) is just the tool for you. Here's how you can use it to protect yourself and your files.

1. Sort Rescue Media

Launch Macrium Reflect Free and choose "Other Tasks > Create Rescue Media" to create a bootable DVD or USB flash drive you can use to recover your Windows installation if something goes catastrophically wrong with your PC.

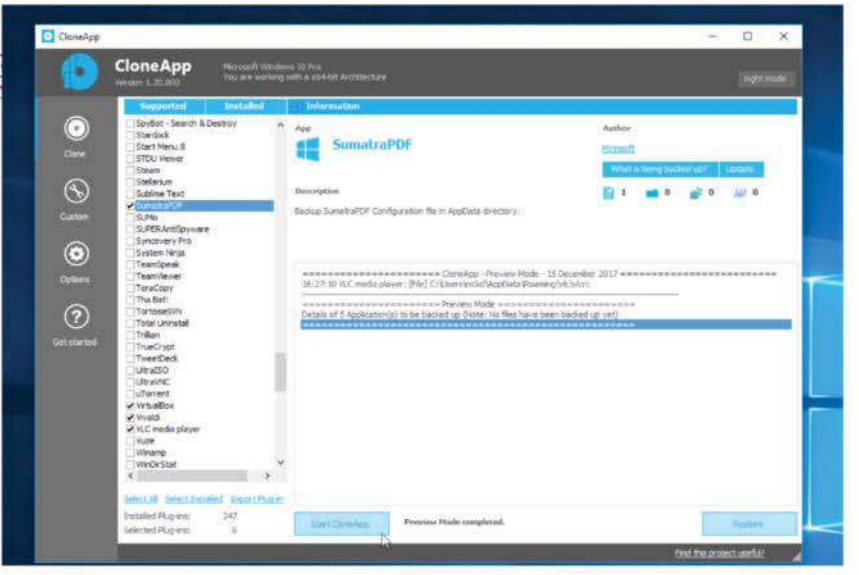
2. Back Up Partitions

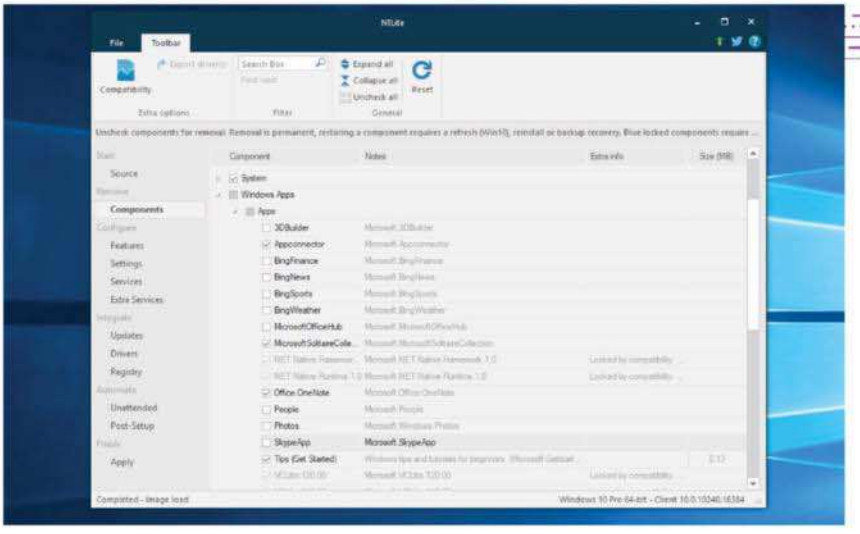
Once you've created your rescue media, click "Create an image of the partition(s) required to backup and restore Windows"—Macrium automatically selects your Windows partition, along with boot partitions required to boot your PC.

CLONEAPP

ONE OF THE MOST time-consuming tasks after reinstalling Windows is restoring program settings. CloneApp (www.mirinsoft.com) enables you to selectively back up key directories and Registry settings where apps store their preferences. Nearly 250 program and Windows settings are plugged into the program—just locate your app, check the box, and it backs everything up, but you can also add your own custom files and Registry entries, too.

Once Windows and your apps have been reinstalled, just launch CloneApp and click "Restore" to put everything back again. To selectively restore program settings, open the CloneApp\Backup directory, and remove any settings you want to exclude before running CloneApp.

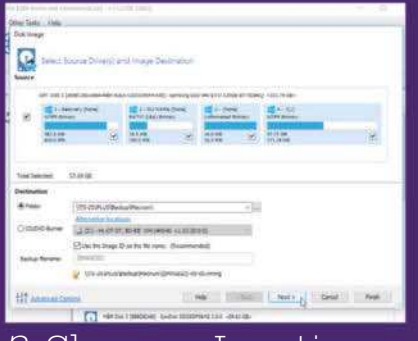




NTLITE

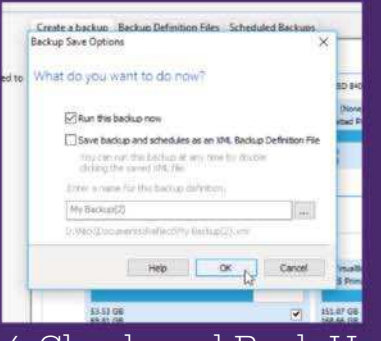
ADVANCED USERS may feel frustrated at constantly having to tweak Windows after installation. NTLite (www.ntlite.com)makes it possible to build customized Windows 7, 8.1, or 10 installation media that not only has all the latest updates included (a boon for Windows 7 users), but which is tailored to your needs, too: You can integrate specific driver packages, remove unwanted Windows components (with built-in safety mechanisms to protect you from inadvertently removing stuff you might need), and perform various tweaks.

Certain features are restricted in the free edition—purchase the full version for €40 (about $47), and you can even perform these tweaks on your current Windows installation, for example.



3. Choose a Location

Click the ellipsis (…) next to "Folder" under "Destination" to select a suitable folder on your backup drive for the partition image. Click "Advanced Options," then check "Verify image…" under "Auto Verify Image," before clicking "OK," followed by "Next."



4. Check and Back Up

Ignore the Schedules screen—this is a one-time fail-safe backup prior to reinstallation. Click "Next," review the backup settings, and click "Finish." Uncheck "Save backup…" and click "OK" for Macrium to back up and verify the image.

PARTITION ASSISTANT

AOMEI'S PARTITION ASSISTANT (www.aomeitech.com) enables you to divide your PC's storage drive into two or more partitions. Why partition your drive? It enables you to separate personal data from Windows and apps. When you next come to reinstall Windows, your files are already safely stored on another drive.

A FULL, DESTRUCTIVE REINSTALL

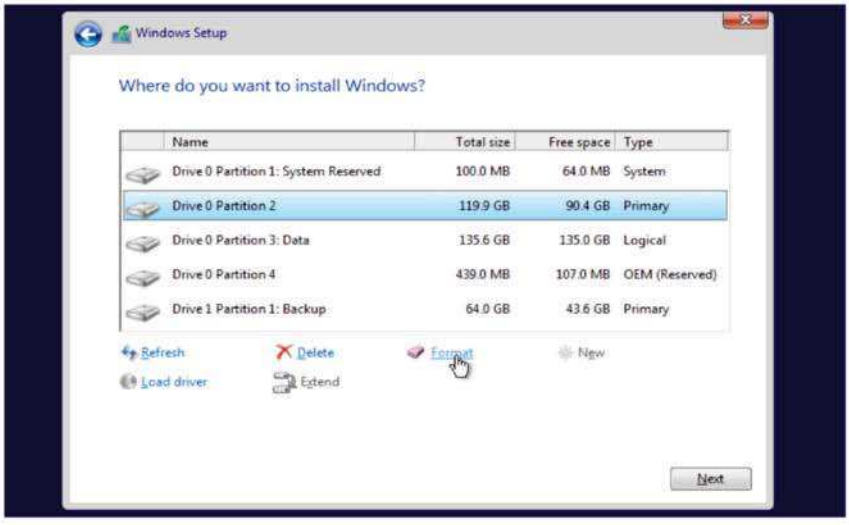
If you're looking to wipe the slate clean, or need to recover from major issues, the nuclear option is always best

Reinstalling Windows from scratch—wiping your system drive clean to install a brand-new (and fresh) version of Windows on it—is the ultimate choice for anyone looking to revive a slow-running PC or resolve a major, non-hardware issue, such as those caused by malware or a clogged-up computer. In this section, we walk you through the entire process.

Ideally, you should have a recent and full backup of your PC, created using either File History or the Windows Backup and Restore tool, before you begin. That way, you'll lose the minimum of content. A full reinstall really is destructive—nothing left on your C drive will exist once you've finished. You should ensure you have the latest installation media for your target version of Windows—see our section on the Windows Media Creation Tool on page 32 for tips on how to do this. This ensures a cleaner, more up-to-date installation from the get-go, saving you time bringing it fully up to date once the installation has completed.

It's also worth sourcing networking and graphics drivers now rather than relying on Windows to provide them—in most cases, they should be built in, but not always. Consult your PC or mobo manufacturer's website for these, or visit your Wi-Fi adapter or graphics card manufacturer's site, and download them to your backup drive.

Other things to consider: Uninstall any products that require activation at this point—this should deactivate the licenses, and enable you to use them with your new install without any issues. Also, be sure to have product keys and program installers to hand.



Windows 10 users can launch a repair install directly from the Media Creation Tool.

Starting the Reinstall Process

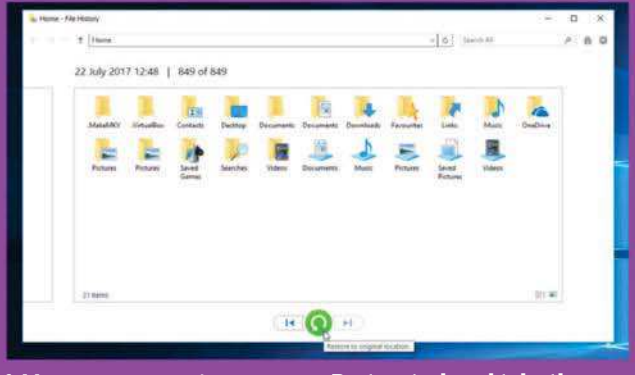
A full destructive reinstall should always be started by booting from your installation media, be it a DVD or USB flash drive. The actual reinstall process doesn't differ much across Windows 7, 8.1, or 10. You are asked to verify your language, location, and keyboard are set correctly, then it's a case of clicking "Install Now." If prompted, enter your product key, or click "Skip" if you're running Windows 10 on a PC you upgraded during the free period. When asked what type of installation you wish to perform, choose the "Custom" option.

Next comes potentially the trickiest part of the process. A list of drives and partitions appears—you need to select the one on which Windows is currently installed. By

RESTORE PROGRAMS, SETTINGS, AND DATA

Once Windows has been reinstalled, open Windows Update to bring your fresh operating system fully up to date—don't be surprised if there are hundreds of updates still to apply in the case of Windows 7 and 8.1. Once it's completely updated, consider reinstalling Macrium Reflect Free (see page 32), and taking your first drive image—a vanilla backup you can restore in future if needed, instead of reinstalling Windows itself.

If you followed the advice on page 33, you should be able to reinstall your core apps using CloneApp from your PC's data drive. If you click "Restore," every program setting you backed up is restored—if there are any you don't want to restore, select "Options" to locate the backup folder, then open it, and move any program folders you want to ignore out of the folder temporarily, before clicking "Restore." Once done, take your second Macrium Reflect Free backup.



Finally, open File History or the Windows Backup and Restore tool, and take the necessary steps to restore any data you backed up, then make sure that either tool is configured to carry on backing up all your precious files going forward.

default, it should be detected and selected, but verify it's correct before clicking "Format" (click "Advanced Drive Options" if it's not visible). Click "OK," then once formatted, verify the drive is still selected, and click "Next."

That's the technical stuff pretty much done. You'll see a checklist of tasks to be performed—just sit back and wait. One thing to note: When Windows reboots, you may see the "Press any key" prompt again to boot from CD or DVD. Don't press anything if that happens, just let the installer continue.

Set Up Post-Install

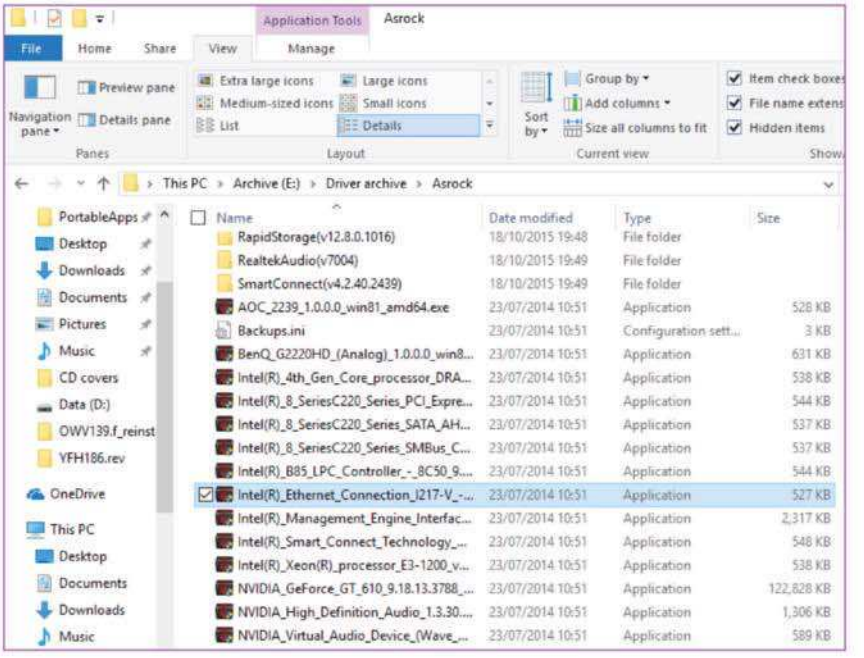
The post-setup prompt begins with Windows 7 users being prompted for their product key, then it's a case of setting up a user account, and you're off and running. Windows 8.1 users get an "Express Settings" prompt—be sure to click the option to customize these, and make sure you go through them carefully.

Post-Creators Update, Windows 10 no longer gives you an "Express Settings" option. For now, confirm your location and keyboard, set up your network if required, and choose "Personal use" when prompted. You can either sign in with your Microsoft account, or click "Offline account → Maybe later," if you plan to stick with the old-style Windows 7 local user account.

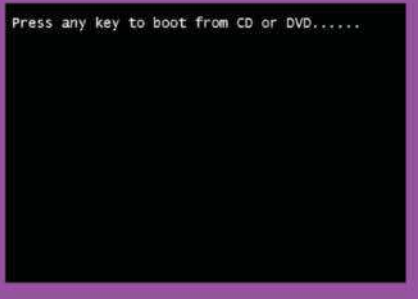
If you opt for the Microsoft account option, now is a good time to set up a PIN to speed up future logins. (Note: The PIN is tied, specifically, to this PC, and you can always bypass it using your regular account password should you forget it at any point.)

You're then asked to set up Cortana—this is where Windows 10's notorious privacy settings come into play, so review all of the options carefully, flicking the slider to "Off" for any you don't need or use.

That's the end of the setup process—Windows now configures itself based on your choices, and you'll see a series of messages appear. Eventually, you'll find yourself back at the Windows desktop.



Make sure you've got network and graphics drivers sourced.

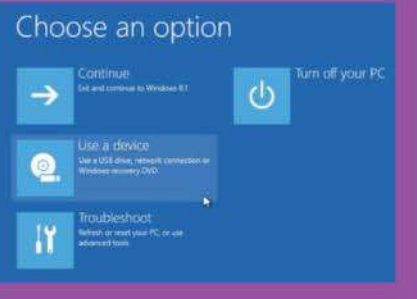


1. Reboot for Media

If you're running Windows 7, or have Fast Boot disabled, insert your boot media, and start your PC. Look for a "Press any key to boot from CD or DVD" option—even if you have booted from a USB flash drive. Press any key on your keyboard, and you should find that the Windows install process starts.

2. Tweak Boot Options

If you boot back into Windows, restart your PC again, but this time press a key, such as F11, when prompted, to open a boot menu. Once you have done so, select your boot media—choosing "UEFI" if that option appears—to boot; otherwise, enter setup so you can change the boot device order.



3. Windows 8.1/10

If Fast Boot is enabled on your computer, open "Settings" in Windows, then navigate to "Update & recovery > Recovery," then click "Restart now" under "Advanced startup." When the boot options appear, choose "Use a device" to select the USB drive or DVD you created from the list that appears.

BUILD THE ULTIMATE SERVER

Use enterprise-level tech to make your home network extra awesome *By Alex Cox*

EXCUSE US BEING a little excitable, but you want the best server. A server that can do it all. A single machine, ready to give you everything you need: media, ad blocking, file serving, the works. But man, what a drag it is to put something like that together—installing all the software, getting it all working with your hardware, balancing the load so that one thing doesn't completely neuter another. Nobody in their right mind would choose to do that if there were a better alternative. And there is. So, while this is a look at creating the best server, we've skewed it as a look at the right way to go about it. Once you have the tools, adding something new to your server will take, literally, a couple of minutes.

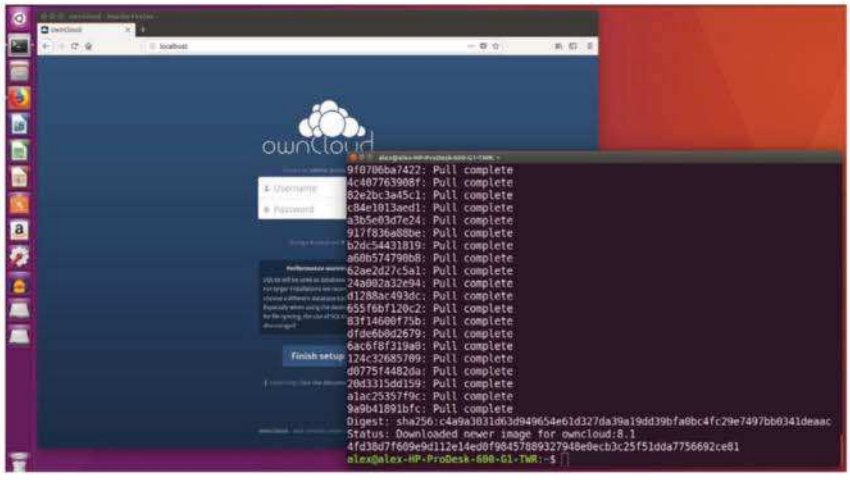
Even better: you don't really need any heavyweight silicon. Sure, some apps (we are looking at you and your transcoding, Plex) would like more CPU cycles than you may be willing to offer, but for the most part, you could run a server full of apps on $35 hardware. Install the right thing, and you can keep tabs on all of the apps on your server, no matter what they are, through a single web interface, accessible from anywhere on your home network.

So, building the best server isn't about the apps. It's about being able to do it properly, finding the right enabler, and using it the right way. We'll take you through everything you need to know to construct a modern, scalable server using enterprise-class software components, without spending a cent on software. And yes, we'll suggest some awesome things you could be running on it, but this isn't our server, it's yours, to do with as you will.

We're not going to stop you building your server in any way you see fit. If you want to install everything traditionally, and run it in the same way you'd fire up software on your desktop, by all means go ahead and do that. But in the enterprise, server technology has moved on. As chipsets improved, RAM increased, and processor overheads exploded, the market moved first toward virtualization and, more recently, toward containerization. And why should the enterprise have all the fun?

It's important to outline the distinction between the two. Virtualization, in the virtual machine sense, is big and heavy. It's a whole operating system in a hefty chunk, and a virtualized system either places the entire demands of an OS on its host, or is forced to scale itself back if the resources aren't available. A virtual machine relies on chipset trickery for intercommunication with shared hardware, and can get its hooks in pretty deep—it's not unreasonable to get performance close to bare metal with a VM.

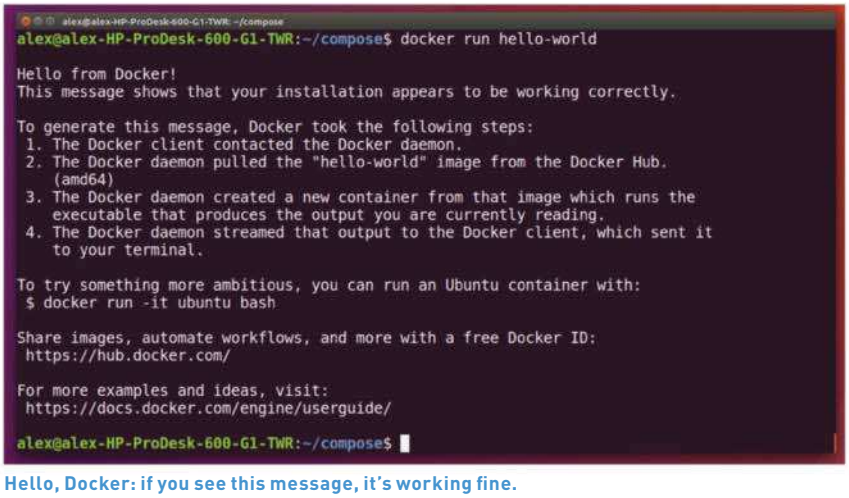
Containerization is not virtualization in the same sense. A container isn't an OS—it's software, everything that software needs, and nothing more, bundled up in a universal package. While VMs represent hardware-level virtualization, containers act at operating system level. Each container on a system relies on an engine layer, which in turn relies on a bunch of kernel components from the base OS—so they're not entirely isolated, although they can get away with some high-level operations. They're super-lightweight, quick to roll out, and can pull off native performance without the overhead of a VM. Indeed, they'll work perfectly happily within a VM; try nesting a bunch of virtual machines inside another VM if you want to hear your hardware cry out in terror.



You need a decent Internet connection and some hard drive space for downloads.

GETTING STARTED

If we're using containers (and, for all the options we offered, we are definitely doing that), probably the best way to look is in the direction of Docker, the platform that broke the back of the concept, and turned it into a reality. Docker is immensely popular, which means there are tons of pre-built containers available, and it scales very well, to the point where you can realistically (albeit sluggishly) containerize a Raspberry Pi (see "Serving Up Pi," below). We're going to run through Docker on a bare-metal Ubuntu installation; you could equally set up a VM and fill it with your own containers, if you don't have the hardware to spare, and don't mind ignoring the point of a server.


alex@alex-HP-ProDesk-600-G1-TWR:~/compose$ docker run hello-world
Hello from Docker!
This message shows that your installation appears to be working correctly.
To generate this message, Docker took the following steps:
1. The Docker client contacted the Docker daemon.
2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
(amd64)
3. The Docker daemon created a new container from that image which runs the
executable that produces the output you are currently reading.
4. The Docker daemon streamed that output to the Docker client, which sent it
to your terminal.
To try something more ambitious, you can run an Ubuntu container with:
$ docker run -it ubuntu bash
Share images, automate workflows, and more with a free Docker ID:
https://hub.docker.com/
For more examples and ideas, visit:
https://docs.docker.com/engine/userguide/
alex@alex-HP-ProDesk-600-G1-TWR:~/compose$
Hello, Docker: if you see this message, it's working fine.

What we don't recommend is running Docker on Windows. While containerization forms a big official part of Windows Server 2016, and there's support for it built in to the Pro and Enterprise editions of Windows 10 post-Anniversary Edition (and also through a combination of VirtualBox and Docker Toolbox), it's a lot more mature on Linux. Admittedly, we're not super-worried about too many of the specifics, or about creating our own super-bespoke containers—basically, we're using an advanced enterprise tool meant for DevOps deployment as an excuse to lazily create a home server, which is cool but not entirely taking full advantage of it. Nonetheless, we still recommend sticking to Linux, and Ubuntu is as good an OS as any.

So, grab the ISO of your preferred flavor of Ubuntu, write it to a USB drive (use Rufus from http://rufus.akeo.ie, it's great), and install it on your server machine. Make sure, during the installation, that you include the Samba and SSH server portions, just so

SERVING UP PI

Make no mistake, a Raspberry Pi is cheap and awesome, but it makes for a poor multi-purpose server. It's pretty much a terrible computer, except for certain applications that don't care about its lack of system resources, and its network bus—shared with USB—is severely limited. That said, for single tasks or light use, it's great, and is the perfect candidate for a few Docker containers. As you might guess from the name, Pihole originated on the Pi, and is one of the best candidates; the Pi can certainly manage a little DNS flinging, and you can realistically get it installed, hide that Pi away, and never worry about ads again. CPU-light apps, or those that are occasionally used, are also fine. The version of Docker that's included with Raspbian needs a quick update before it works properly, so run `curl -sSL https://`

A docker_compose.yml is just a text file full of copied and pasted parameters.

it's easy enough to control from another machine on your network. You'll be glad of this once your server is disconnected from peripherals and shoved under the stairs. Once it's running, open up a terminal, and begin the process of installing the stable thread of Docker Community Edition.

GET DOCKER SET

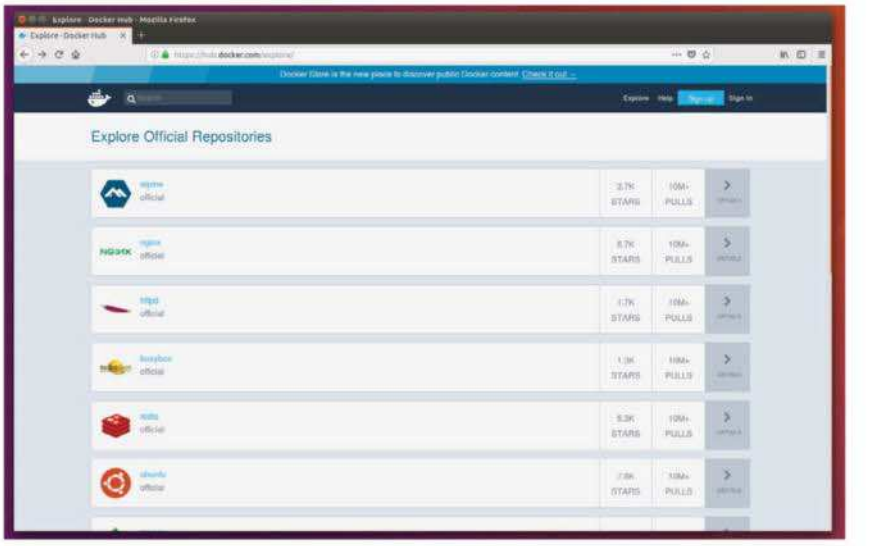
We want to grab the latest version of Docker from its own repository, but in order to do that, we need to start by installing the prerequisites for adding that repository as a source. Run `sudo apt-get update` to get your Ubuntu installation up to speed, then `sudo apt-get install apt-transport-https ca-certificates curl software-properties-common` to ensure you have all the relevant tools. Now use `curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -` to grab Docker's GPG key, followed by `sudo add-apt-repository "deb [arch=amd64] https://download.docker.com/linux/ubuntu $(lsb_release -cs) stable"` to add the repository itself. Run `sudo apt-get update` again to refresh Ubuntu's package list and, if all has gone well, you can run `sudo apt-get install docker-ce` which will pull down and install Docker Community Edition, along with all of its dependencies.

With that done, it's time to show just how incredibly easy it is to get things running with Docker, by pulling down a complete image from its servers and running it in a container. Ready? Run `sudo docker run hello-world` and see what happens. That's it. The whole thing. Docker has contacted its servers, pulled down the image "hello-world," started a new container based on that image, and piped its output into your terminal. You've run a containerized application, however useless it may be, and you can call `sudo docker info` to prove it: It'll list one stopped container. We recommend following the steps in "Quality of Life" (over the page) now, so you don't have to append "sudo" to the start of every command that follows.

ADDING CONTAINERS

Running other containers isn't always as straightforward as that "Hello World" example, but it's not necessarily far off. Try, for example, `docker run -d -p 80:12345 owncloud:8.1` to start a container with an image of the OwnCloud file server within, then open up a web browser on your server machine, and go to http://localhost:12345 to see the results. It's pretty immediate, although we've had to add a few additional parameters this time. For example, `-d` tells Docker to run the container in detached mode, managing it in the background, rather than filling your console with status messages, and `-p` tells it to pass the port of the container to the host machine— `80:12345` is our port mapping, piping port 80 of the container to port 12345 of the host machine. When you're running multiple containers with a web interface, you'll want to map them to different ports.

That image, after first running, has been cloned to your system. Reboot your machine and run `docker image ls` to list all the containers that exist on your system, and you'll see it there; run the same command as before to start it up, and Docker won't



Dig through the Docker Hub to find containers for basically every useful package out there.

`get.docker.com |sh` **to install afresh.**

While Docker runs fine on a Pi (far better than any traditionally virtualized solution), images are often built for X86 platforms rather than the Pi's ARM. Even the standard hello-world image won't work; to test a Pi Docker installation, you need to run `docker run armhf/hello-world`**. When searching for candidates or containerization, be sure there's an ARM64 version. Visiting https://hub.docker.com/u/arm64v8/ brings up a number of options, all created internally within the Docker team. Or why not use your Raspberry Pi as a Tor relay with the brunneis/tor-relay-arm image, or install one of any number of programing environments? You could even use Deluge to set up your Pi as a hub for all your torrents, or try Pydio for a little simple online file storage.**

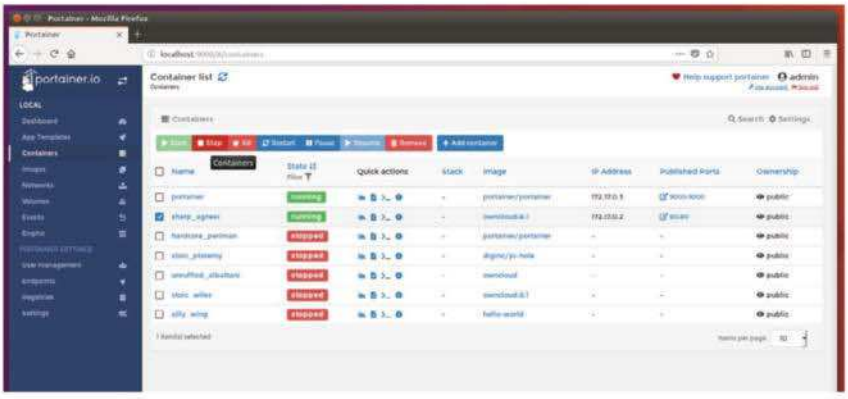
redownload it—it runs the local version instead. But now, before we start wantonly installing the apps that are going to make our server so great, it's time to up the complexity a little, and look at running and configuring a proper collection, and for that we need docker-compose, which combines a bunch of containers into a single application.

GOING MULTIPLE

Time for a little admin. Install Docker Compose with `sudo curl -L https://github.com/docker/compose/releases/download/1.21.2/docker-compose-$(uname -s)-$(uname -m) -o /usr/local/bin/docker-compose` (replacing that version number with the very latest version, which you can find at http://github.com/docker/compose/releases), then give it the permissions it requires with `sudo chmod +x /usr/local/bin/docker-compose`. Working with Docker Compose is, like its sibling, ridiculously easy. Basically, you need to build a configuration file that tells it which containers you want to run, and feeds in the parameters they need to operate properly, then it goes off and does its thing. To make that even more simple, most applications offer a template for precisely what needs to go into the configuration file, and all you need to do is fill in the blanks. So, let's walk through a simple Docker Compose installation, using ad-blocking DNS manager Pihole as an example.

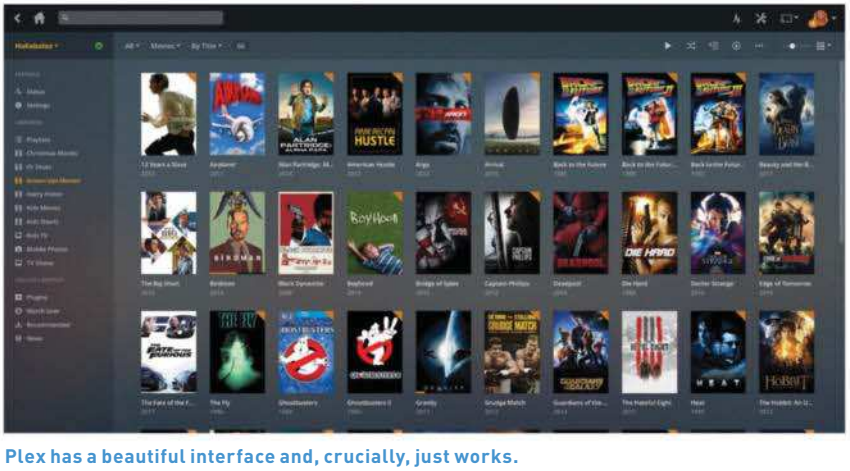
To do so within Docker Compose, you first need to generate the configuration file; make a new directory for it with `sudo mkdir ~/compose`, and change to it with `cd ~/compose`. Create a working folder for Pihole with `sudo mkdir /var/pihole`, give it permissions using `sudo chown -R <your username>:<your username> /var/pihole`, then run `sudo nano docker-compose.yml`, and enter the following into the file, switching "LANIP" for your server's IP address, and paying special attention to the spacing—each tab should be two blank spaces:

```
version: '2'
services:
 pihole:
   restart: unless-stopped
   container_name: pihole
   image: diginc/pi-hole
   volumes:
     - /var/pihole:/etc/pihole
   environment:
     - ServerIP=LANIP
   cap_add:
     - NET_ADMIN
   ports:
     - "53:53/tcp"
     - "53:53/udp"
     - "80:80"
```



Portainer simplifies the process of managing a server with numerous containers.

Now just run `docker-compose up -d`, and Pihole should be up and running—if not, it could be conflicting with another process (such as dnsmasq) that takes control of port 53. To kill that off, run `sudo sed -i 's/^dns=dnsmasq/#&/' /etc/NetworkManager/NetworkManager.conf` to remove it from the relevant config file, then `sudo service network-manager restart /` and `sudo service networking restart`, followed by `sudo killall dnsmasq` to make sure it's really, truly dead. You can check your results by heading to http://localhost/admin in a web browser. Adding further containers to your combined application is just a case of adding their parameters to the `docker-compose.yml` file, then running it again. To use Pihole's DNS sinkhole facilities properly, you now need to configure your router to route DHCP clients through your server.



Plex has a beautiful interface and, crucially, just works.

THE POWER PACK

So that's the how. What about the what? Start digging through http://hub.docker.com, because just about everything you could possibly want has been put in a neat package for you. File management, for example: OwnCloud, as mentioned before, offers up a Dropbox-esque way of managing

QUALITY OF LIFE

If you're running a Docker server, you'll want to be as hands-off as possible. That means giving Docker slightly more access, but on the flip side, it means a slight reduction in security, so it's up to you if you wish to follow these steps. First, create a new group just for Docker by using `sudo groupadd docker`, then add your current user to the docker group with `sudo usermod -aG docker $USER`. Log out, then log back in, and you should now be able to run Docker commands (try `docker run helloworld`) without prepending them with `sudo`. If you see an error, it's probably a permissions issue with your ~/.docker/ folder, caused by using `sudo` previously; you can either kill your existing folder with `rm -f ~/.docker/` and

MANAGING MULTIPLE CONTAINERS

Netdata's live graphs and alerts give a total picture of your server's health.

Eventually, you're going to find your server lacking ports. Pihole, for example, really needs to take control of port 80, because your HTTP traffic is routed through it—but what if another container also needs to use port 80? It's possible, as we've seen, to remap those ports in your docker-compose.yml, piping port 80 from the container to any other free port on the host, but that's much more awkward than it needs to be when you're connecting to your server from elsewhere. Combining a little DNS management with a reverse proxy (we're partial to nginx-proxy) means all requests to your server are collected and rerouted to the appropriate container based on the hostname used; plex.maximumpc.local, for example, might take you to your Plex server without the need to remember which port it's living on. Nginx can also take charge of load balancing and traffic management between your server containers—check out https://github.com/jwilder/nginx-proxy for information on getting it running, and look at installing dnsmasq (https://hub.docker.com/r/strm/dnsmasq/) within a container to deal with local DNS remapping.

Although Nginx (pronounced "Engine X," as we were told after saying "Nn gincks" a few too many times) can deal with load balancing, and our containerized server should theoretically be able to dole out its resources sensibly, a little monitoring layer is a great choice to see just where that load is going. Grab the image titpetric/netdata and get that running. Netdata provides not only insight into the movements of your various containers, but offers up an absolutely live and extremely well-explained look at the deeper aspects of your server hardware. If something's not working as it should—or even if you have a minor driver issue—you'll know about it first.

your files, with a web interface that offers simple password-protected access to a bin of files from every device in your home—including mobile clients. Nextcloud does much the same job as OwnCloud, but if you'd like to go more raw, you could fire up an SFTP server (try the atmoz/sftp image), or containerize a Samba installation (kartoffeltoby/docker-nas-samba) to give your server fuss-free NAS capabilities.

Media next, and you're spoiled for choice. Plex, using the officially sanctioned plexinc/pms-docker image, is our top choice for home (and beyond) media server duties, but you don't have to run it alone. There are various tools that can enhance your media-getting capabilities, although we can't say too much about them here. Head over to http://linuxserver.io and check out the most-downloaded images if you'd like to see which are the most popular. Once you're all lined up, be sure to add the excellent linuxserver/plexpy, which helps you keep tabs on precisely what's going on with the traffic and files running through your Plex server. The back end portion of Kodi is also a solid choice, although in our opinion, Plex is a much more adept file-wrangler.

Your server could perform more esoteric archiving and organizational duties, too. Try Mediawiki to get an instant home wiki up and running, perfect for recording significant information, or Photoshow (linuxserver/photoshow) to quickly install a database-free photo gallery with drag-and-drop uploading. Vault (http://vaultproject.io) isn't pretty, but it's a great place to hide secrets, giving you a sealable safe for passwords, keys, and other critical security information. Home Assistant (homeassistant/home-assistant) can, after a bit of wrangling, take control of all your smart gear in one place.

MAKING IT EASIER

Once you start piling on the containers, make sure you manage them (and their increasingly irritating port demands) well—see "Managing Multiple Containers" above. And although putting together a docker-compose.yml isn't taxing, you can get more granular control over containers with Portainer (http://portainer.io), which throws up a web interface in which you can start, stop, or add new containers at will. Organizr (lsiocommunity/organizr) is also useful, pulling all your media server apps into a single interface, and allowing you to distribute them selectively to family members—try running two Plex containers, for example, to split family-friendly content from the material you wouldn't want your kids to get hold of. Point them to Organizr, and they'll only see what you've allowed. Consider, also, Watchtower, which monitors your images for changes, and automatically updates them to the latest versions.

If, rather than making things easier, you'd like to make them slightly more difficult, but a lot more personal, look into creating your own containers. It's complex, but Docker's documentation covers the process in a huge amount of detail—head to http://docs.docker.com to learn about the required components and relevant commands. Once you've made your own container, upload it to the Docker hub, where anyone (including future-you) can pull it back down to their own machine, and replicate it exactly.

start again, or give the folder the appropriate permissions, first with `sudo chown "$USER":"$USER" /home/"$USER"/.docker -R`, then with `sudo chmod g+rwx "/home/$USER/.docker" -R`. Make sure you offer similar permissions to other folders you create, for storing data or media in your containers.

It's handy to have Docker run automatically upon boot, so you don't need to grab your peripherals (or log in via SSH) to get your server back up and running if you power cycle. Just add Docker to Systemd, the Linux component that (in most modern distributions) deals with managing the processes that run at boot time, by running `sudo systemctl enable docker` within your command line. Type `systemctl` to check it's worked—dig through the list until you see "docker.service" listed. If you ever change your mind, you can reverse the action with (you guessed it) `sudo systemctl disable docker`.

SUBSCRIBE TO MAXIMUMPC

THE GO-TO RESOURCE FOR PC ENTHUSIASTS...

CHOOSE YOUR PERFECT PACKAGE

MAXIMUMPC
SPEED UP WINDOWS
Make your machine run like new again
Solve all of your OS problems
Clean out the junk for faster booting
VIDEO ENCODING 101

1

THE DIGITAL EDITION
ONLY $9.00
EVERY YEAR

Instant digital access on your iPad, iPhone, and Android device.

MAXIMUMPC
SPEED UP WINDOWS
Make your machine run like new again
Solve all of your OS problems
Clean out the junk for faster booting
VIDEO ENCODING 101
STEP-BY-STEP GUIDE

2

THE PRINT EDITION
ONLY $24.00
EVERY YEAR

Every issue delivered to your door for a fraction of the store price.

3
COMPLETE PRINT & DIGITAL BUNDLE
ONLY $28.00
EVERY YEAR

Get the print edition of *Maximum PC* delivered direct to your door, and instant access on your iPad, iPhone, or Android device.

MAXIMUM PC
SPEED UP WINDOWS
Make your machine run like new again
Solve all of your OS problems
Clean out the junk for faster booting
VIDEO ENCODING 101
STEP-BY-STEP GUIDE
OPTIMIZE UPGRADE
Smash bottlenecks to unleash your PC's full potential
REAL-TIME RAY TRACING

On iOS & Android!

THE EASY WAYS TO SUBSCRIBE...

http://bit.ly/sub-maxpc

Or call 844-779-2822 (toll-free)

TERMS AND CONDITIONS Prices and savings quoted are compared to buying full-priced US print and digital issues. You will receive 13 issues in a year. You can write to us or call us to cancel your subscription within 14 days of purchase. Your subscription is for the minimum term specified, and will expire at the end of the current term. Payment is non-refundable after the 14-day cancelation period, unless exceptional circumstances apply. Your statutory rights are not affected. Prices correct at time of print and subject to change. Call center opening hours are Monday to Friday 8am–7pm, and Saturday 10am–2pm EDT. For full terms and conditions, please visit http://bit.ly/magtandc. **Offer ends: August 31, 2018.**

TECH PORN

PERFORMANCE GEAR LAID BARE

AOC 1601FWUX

FOR DEDICATED DESK JOCKEYS forced to leave the house, there's nothing quite as frustrating as abandoning a set of beautiful 4K screens and being forced to go caveman, working with a pathetic single built-in panel. In these modern times, it just ain't right. Thankfully, not for the first time, and certainly not for the last, the mighty bandwidth and power delivery talents of USB-C are here to save us, in combination with AOC's masterfully thin portable panel. It's a plug in and go affair: As long as your laptop has a 3.1-capable USB-C socket (there's no backward compatibility with USB 3.0), you can hook it up, prop it up, and get your multi-screen on wherever you may be, using a single slimline cable for power and data. Even with those chunky bezels, the slender profile, ease of attachment, and incredibly light weight of the 15.6-inch 1601FWUX make it a drool-worthy item to have in your bag. **–ALEX COX**

1 Pretty Panel

There's nothing lacking in the bread and butter. The 1601FWUX offers a decent 1080p resolution, which—given the screen's relatively small size—doesn't over-emphasize the pixels. Bonus points, too: It's a WVA IPS panel that manages damn strong color reproduction and solid viewing angles. Realistically, it'll probably put the panel that's built into your laptop to shame.

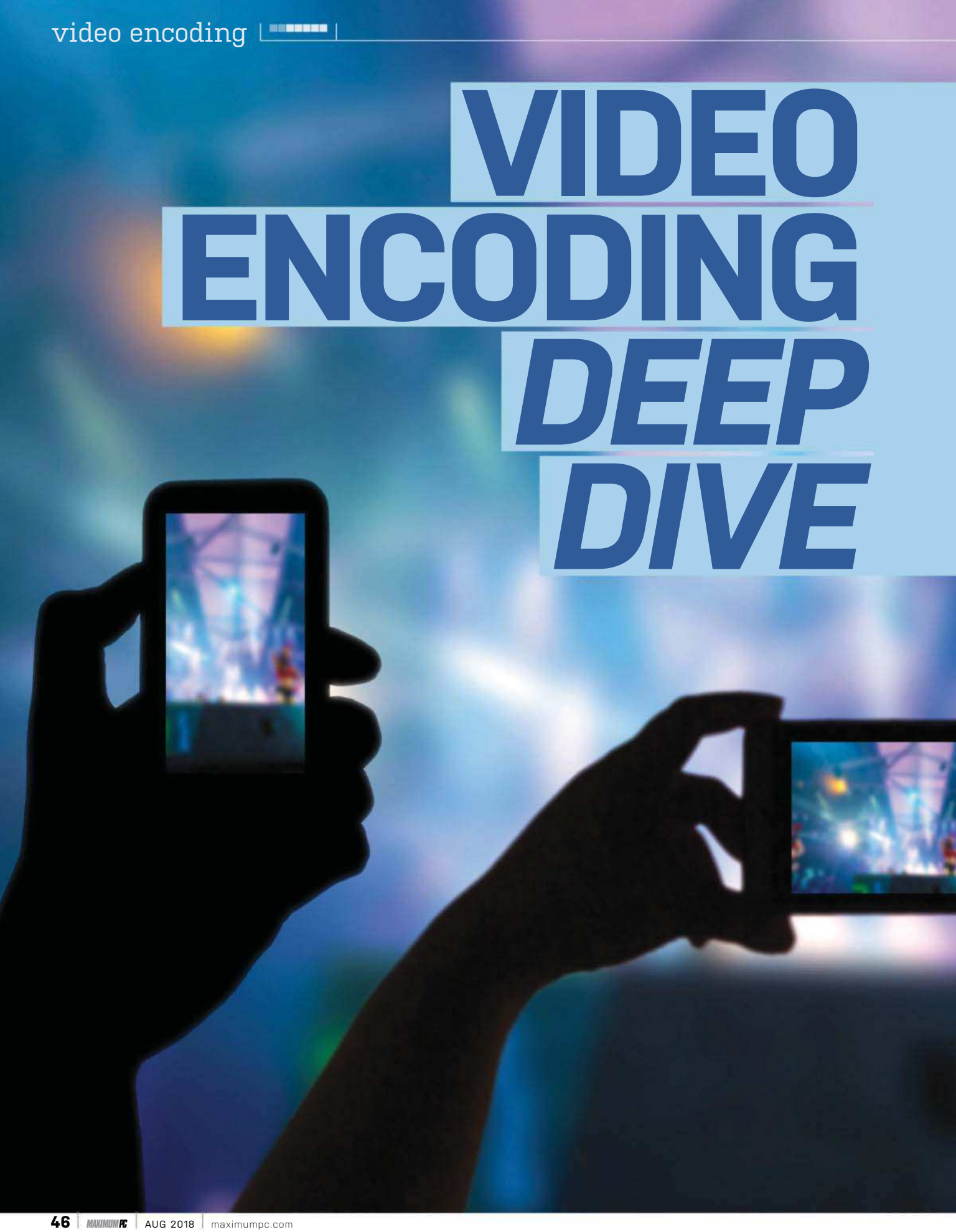
2 Auto-Rotate

Portrait mode is a woefully underrated function of modern monitors. You're not going to game on it unless you're seriously masochistic (and your chosen title is crazy enough to let you use a vertical resolution), but for idly flicking through the Internet or hitting up high-value spreadsheets, it's invaluable. The 1601FWUX's automatic rotation detection means you can switch it up whenever you need it.

3 Magmount

The 1601FWUX's essential accessory is its stand, a foldable magnetic thing that gives you a decent range of adjustment, from lazily laid-back to beyond vertical, perfect to keep the mat screen free of any environmental glare. In a neat twist of industrial design, that same stand doubles as a cover for the screen. Clack its magnets on to the front, and you're protected on the move.

VIDEO ENCODING DEEP DIVE



Next-gen encoders deliver better quality with smaller files; get up to speed now

A NEW GENERATION of video encoders is upon us! Some sound familiar, such as H.265, some sound exotic and new, like VP9 or AV1, but no matter what, you're likely be tripping over one or the other soon, and cursing that your CPU use has shot through the roof.

Why do we need a raft of new encoders? Why has your hardware acceleration stopped working? Is that 4K file going to play on your 4K UHDTV? What about HDR on the PC? How can you encode your own video, and can you even enjoy some GPGPU acceleration, too? Can we make it all simple for your perplexed brain?

We're going to take a deep dive into the inner workings of video encoders to see how gigabytes of data can be compressed 100 times and the human eye can't tell the difference. It's going to be like the math degree you never got around to taking at community college, but probably a lot more useful!

If you want to control your encodes better, it really does help to have an understanding of what's going on inside the encoder. Ironically, none of these standards defines the encoder, just what's required for the decoder. As we'll see, this does enable the encoder writer to use all manner of techniques and user settings to enhance encodes, usually at the expense of longer encode times and more processor usage, for either a smaller file or enhanced quality.

BY NEIL MOHR

TAKE YOUR LINUX KNOWLEDGE FURTHER

Enhance your knowledge with in-depth projects and guides

BOOKAZINE
HACKER'S MANUAL 2018
FULL OF EXPERT TIPS & ADVICE
ADVANCE YOUR LINUX SKILLS
• THE KERNEL • NETWORKS
• SERVERS • HARDWARE • SECURITY
180 PAGES OF TUTORIALS
ENHANCE YOUR KNOWLEDGE WITH IN-DEPTH PROJECTS AND GUIDES
FUTURE

ON SALE NOW

Ordering is easy. Go online at:

www.myfavouritemagazines.com

Or get it from selected supermarkets, newsagents, or bookstores

ONCE UPON A TIME, there were animated GIFs, and boy those things were terrible. You can see the problem: People want to store moving images on their computers, and a fixed 256-color palette standard that stored full frames was not the future; this was back in 1987.

What we've had since then is 30 years of steady encoding enhancements from a well-organized international standards committee. Well, up until the last decade, but we'll come to that.

We're not going to dwell on the history, but it's worth noting a couple of things that have fixed naming conventions and systems in place. Before moving images, there were still images. The first working JPEG code was released at the end of 1991, and the standard in 1992, out of the work by the Joint Photographic Experts Group, which started working on JPEG in 1986.

Similarly, the International Telecommunications Union (ITU) formed the Video Coding Expert Group (VCEG) way back in 1984 to develop an international digital video standard for teleconferencing. That standard was the first H.261, finalized in 1990, and designed for sending moving images at a heady 176x144 resolution over 64kb/s ISDN links. From this, H.262, H.263, H.264, and H.265 were all born, and after H.261, the next video standard worked on was known as MPEG-1.

So, you can see where these standards came from. We've mentioned JPEG for two reasons: First, MPEG (Moving Picture Experts Group) was formed after the success of JPEG. It also used some of the same techniques to reduce encoded file size, which was a huge shift from existing lossless digital storage to using lossy techniques.

One of the most important things to understand about modern lossy compression is how the image is handled and compressed. We're going to start with the basics, and how JPEG compression [Image A] works—it's at the heart of the whole industry—and expand that knowledge into motion pictures and MPEG. Once we've got that under our belt, we'll see how these were improved and expanded to create the H.264 and H.265 we have today.

SPACE: THE COLORFUL FRONTIER

The first thing to get your head around is the change in color space. You're probably used to thinking of everything on PCs stored in 16-, 24-, or 32-bit color, spread over the red, green, and blue channels. This puts equal emphasis on storing all color, hue, and brightness information. The fact is, the human eye is far more sensitive to brightness, aka luminance, than anything else, then hue, and finally color saturation.

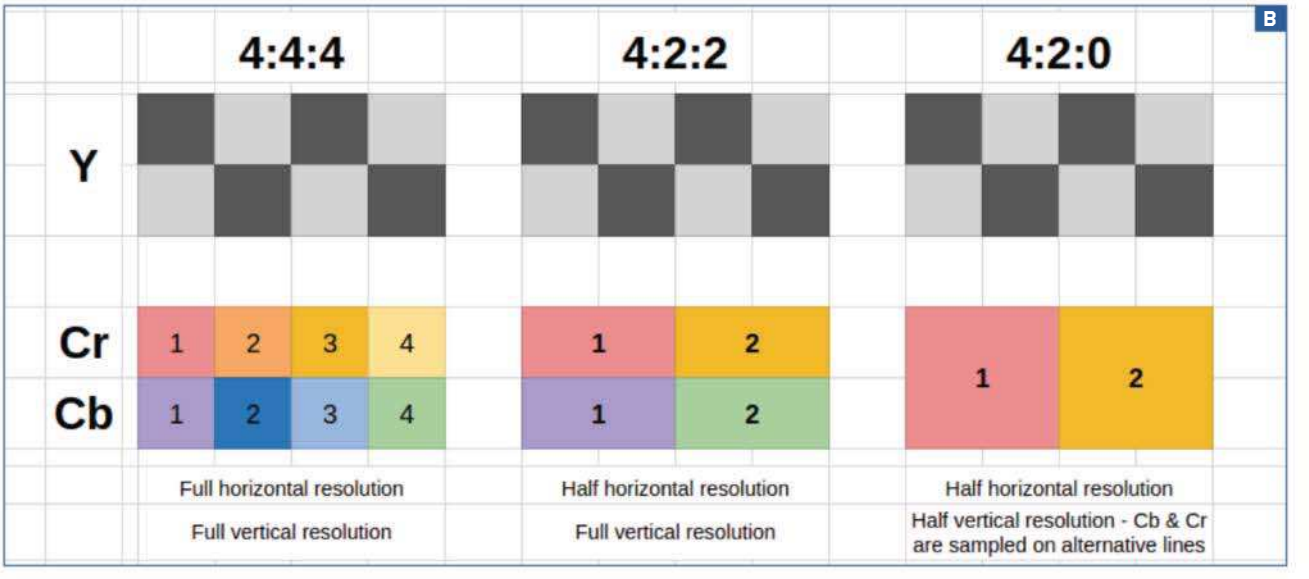
The color space is changed from RGB to YCbCr, aka luminance and two chrominance channels (blues and reds here)—if you're wondering, this is related to YUV. The reason is to enable chroma subsampling of the image; that is, we're going to reduce the resolution of the Cb and Cr channels to save space without any perceivable drop in quality.

You can see the JPEG compression struggling to retain detail at low-quality settings.

This is expressed as a ratio of the luminance to the chroma channels. The highest quality—full RGB—would be 4:4:4, with every pixel having Y, Cb, and Cr data. It's only used in high-end video equipment. The widely used 4:2:2 has Y for every pixel, but halves the horizontal resolution for chroma data; this is used on most video hardware. 4:2:0 keeps horizontal resolution halved, but now skips every other vertical line [Image B]—this is the encoding used in MPEG, every H.26x standard, DVD/Blu-ray, and more. The reason? It halves the bandwidth required.

THE SCIENCE BIT

Now the heavy math kicks in, so prepare your gray matter.... For each channel Y, Cb, and Cr, the image is split into 8x8 pixel blocks. With video, these are called macroblocks. Each block is processed with a forward discrete cosine transform (DCT)—



Here's how the color channels are sub-sampled for different color spaces.

CAN YOU HEAR ME?

Conspicuous by its absence so far in this feature has been talk about audio. We're going to go out on a limb here, and suggest that no one really cares any longer when it comes to standalone audio encoding. We're sure there's the odd reader who still has a multi-gigabyte collection, but they're like the vinyl hoarder—more an exception than a rule. It feels as though the way people consume their audio has changed drastically, from the old owner/collector system, to a new streamer/subscriber model.

Even taking that into account, if you are going to be storing your own audio, if you care in any way, you're going to be using a lossless codec. Because storage is cheap, and FLAC should be your preference, there's not too much to cover. If you don't care, you're likely happy to keep on using MP3 encoding, though you should be using Ogg Vorbis.

Both of these standards are open (actually, MP3 is also open as the patents have expired), so technically can be supported by anyone who cares to. FLAC has wide industry backing, including Windows, MacOS, iOS, Android, and something called Linux. As important, its device support is top-notch, including Sonos, a host of in-car systems, Denon, Synology, and Plex, to name a few. Ogg has more limited support, but can be supported by Windows, MacOS, and iOS.

Some might point out that a newer format, Opus, offers even greater quality with its lossless format, but its youthfulness means hardware support is more limited than Ogg.

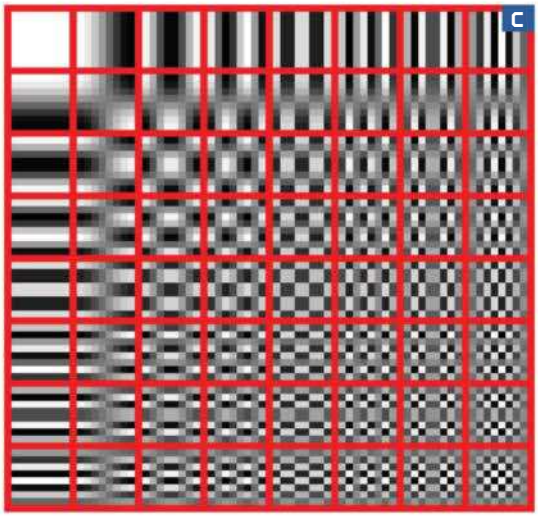
The bestest and oddest-named codec in the world: Flac!

of the type two, in fact. "What the heck is that?" we hear you ask. We unleashed our tamed *Maximum PC* mathematician from his box, who said it was pretty simple. Well, he would! Then he scurried off, and installed Arch Linux on all our PCs. Gah!

The DCT process transforms the discrete spatial domain pixels into a frequency domain representation. But of what? Take a look at the 8x8 cosine grid—the black and white interference-like patterns [Image C]. The DCT spits out an 8x8 matrix of numbers; each number represents how much like the original 8x8 image block is to each corresponding basis function element. Combine them with the weighting specified, and you get a close enough match to the original that the human eye can't tell the difference.

As you'll spot, the top-left basis function element is plain (described as low frequency), and will describe the overall intensity of the 8x8 grid. The progressively higher frequency elements play less and less of a role describing the overall pattern. The idea being we're able to ultimately drop much of the high-frequency data (the details parts) without loss of perceived quality.

This DCT matrix is run through a 8x8 quantizer matrix; standard matrices are provided (based on researched amounts), but software encoders can create their own for, say, 50 percent quality, as it goes along. The quantizer is devised to try to retain low-frequency detail—which the eye sees more easily—over high-frequency detail. Each DCT element is divided by each corresponding quantizer element, and the result rounded to the nearest integer. The end result is a matrix with low-frequency elements remaining in the top-left of the matrix, and more of the high-frequency elements reduced to zero toward the bottom-right of the matrix, which is where the lossless element of JPEG comes in [Image D].



©WIKIPEDIA

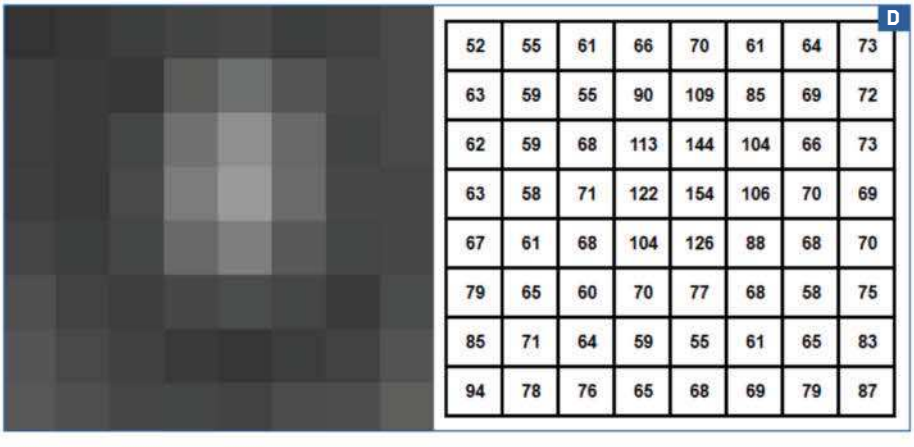
Every image can be roughly made up from this. Math!

Due to this top-left weighting, the matrix is rearranged into a list using a "zig-zag" pattern, processing the matrix in diagonals, starting top-left, which pushes most zeros to the end [Image E]. Huffman Encoding compresses this final data. Quality of the JPEG image is controlled by how aggressive the quantizer matrix is. The more strongly it attempts to round down elements to zero, the more artifacts. Congratulations—you've compressed a still image!

If JPEG is so good at compressing, why not stick a load together to make a moving image format? Well, you can—it's called Motion JPEG—but it's hugely inefficient compared to the moving picture encoding schemes.

MOTION COMPRESSION

For MPEG (and other compression schemes), each frame is split into



Take the values of a single-channel 8x8 pixel grid into a matrix.

macroblocks of 16x16 pixels. Why not the 8x8 that is used by JPEG and used within the MPEG standard? Well, MPEG uses 4:2:0 color space, which skips every horizontal line, so we need to double up to retain an even amount of data horizontally and vertically.

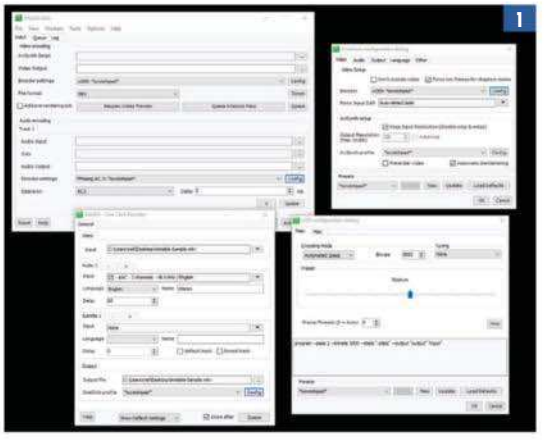
The MPEG standard uses three types of frame to create a moving image. I (intra) frames are effectively a full-frame JPEG image. P (predicted) frames store only the difference between an I-frame and the future P-frame. In between these is a series of B (bidirectional or inter) frames, which store motion vector details for each macroblock—B-frames are able to reference frames before and upcoming.

So, what's happening with motion vectors and the macroblocks? The encoder compares the current frame's macroblock with adjacent parts of the video from the anchor frame, which can be an I or P frame. This is up to a predefined radius of the macroblock. If a match is found, the motion vector—direction and distance data—is stored in the B-frame. The decoding of this is called motion compensation, aka MC.

However, the prediction won't match exactly with the actual frame, so prediction error data is also stored. The larger the error, the more data has to be stored, so an efficient encoder must perform good motion estimation, aka ME.

Because most macroblocks in the same frame have the same or similar motion vectors, these can be compressed well. In MPEG-1, P-frames store one motion vector per macroblock; B-frames are able to have two—one from the previous frame, and one from the future frame. The encoder packs groups of I, P, and B frames together out of order, and the decoder rebuilds the video in order from these out of the MPEG bitstream. As you can imagine, there's scope for the encoder to implement a wide range of quality and efficiency variables, from the ratio of I, P, and B frames to its motion compensation efficiency.

At this point, we've covered the basics of a compressed MPEG-1 video. Audio is integrated into the bitstream, and MPEG-1 supports stereo MP3 audio. We're not going to go into the audio compression. MPEG-2 (aka H.262) [Image F] uses largely the same system, but was enhanced to support a wider range of profiles, including DVD, interlaced video, higher-quality color spaces up to 4:4:4, and multi-channel audio. MPEG-3 was rolled into MPEG-2 with the inclusion of 1080p HD profiles.



MeGUI, it's all about me, me, me, me, me!

MPEG-4: ZOOM AND ENHANCE

MPEG-4—aka H.264—started off with the aim of enhancing the standard for digital streaming. Getting better image quality from half the bitrate. But with the advent of Blu-ray and HD DVD (remember that?), the extension

DCT produces a frequency domain matrix; we quantize this to get the final lossy compressed matrix.

E

-415.3	-30.2	-61.2	27.2	56.1	-20.1	-.2.4	0.46
4.47	-21.86	-60.8	10.25	13.15	-7.09	-8.54	4.88
-46.8	7.37	77.13	-24.5	-28.9	9.93	5.42	-5.56
-48.5	12.07	34.1	-14.76	-10.25	6.3	1.83	1.95
12.12	-6.55	-13.2	-3.95	-1.87	1.75	-2.79	3.14
-7.73	2.91	2.38	-5.94	-2.38	0.94	4.3	1.85
-1.03	0.18	0.42	-2.42	-0.88	-3.02	4.12	-0.66
-0.17	0.14	-1.07	-4.19	-1.17	-0.1	0.5	1.68

-26	-3	-6	2	2	-1	0	0
0	-2	-4	1	1	0	0	0
-3	1	5	-1	-1	0	0	0
-3	1	2	-1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

ENCODING WITH MEGUI

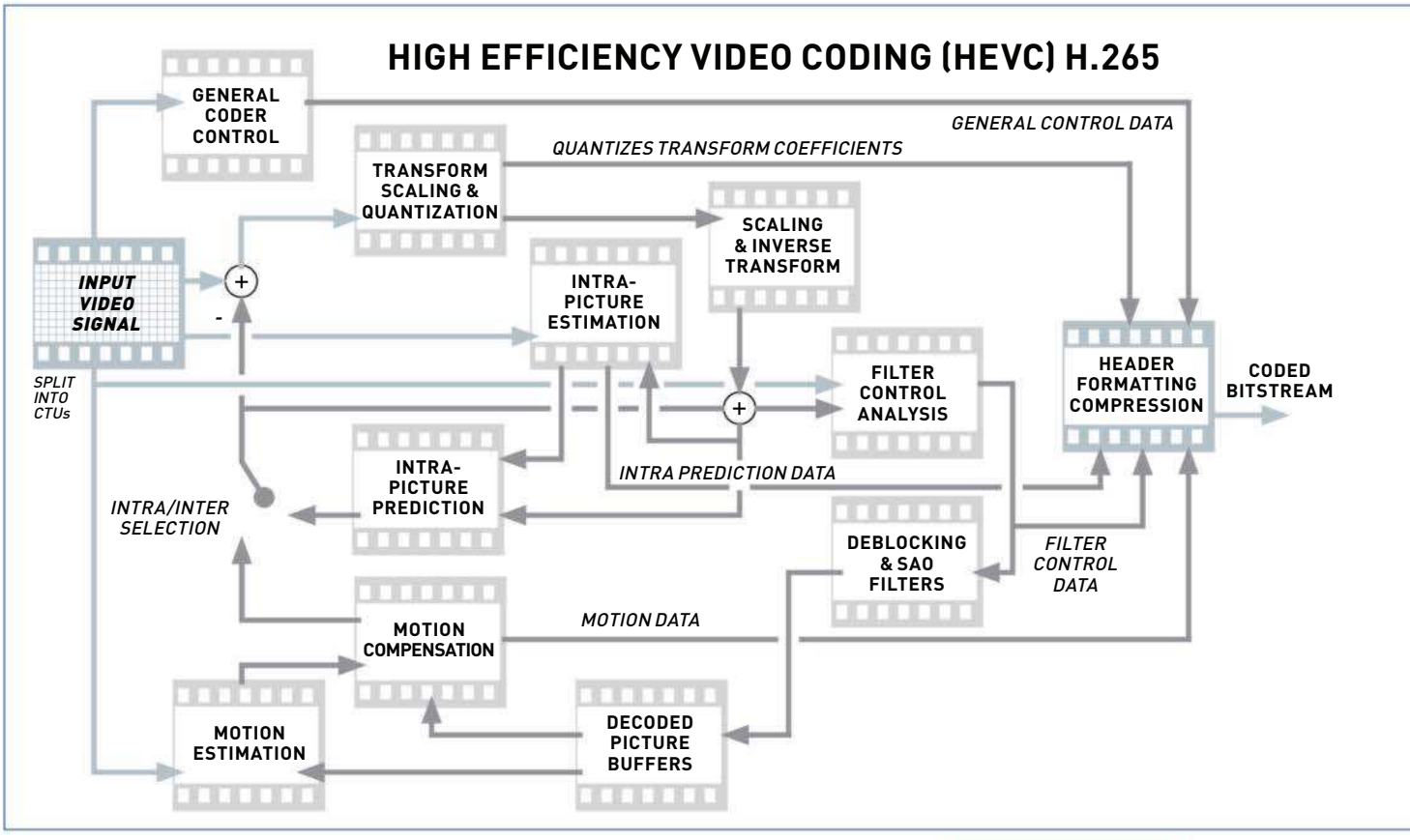
If you're at all interested in quality video encoding, then there's a host of solutions offering their services out there. Handbrake.fr is often suggested as a good open-source option, but it appears to be looked down upon by many of those in the know. A better suggestion appears to be MeGUI [Image 1], which has been developed by the brainiacs on the ancient http://forum.doom9.org site.

MeGUI is open-source licensed GPL v2, it's still under active development, it supports x.264 and x.265 out of the box, and it automatically updates all the many required components as it ticks along—this means that the first time you encode something, there's a number of additional waits while it downloads the necessary components. It's all very slick.

Plenty of handy documentation and guides can be found at https://en.wikibooks.org/wiki/MeGUI, while you'll be pointed toward https://sourceforge.net/projects/megui for the main download. Just grab it, extract, and you're ready to go!

Originally developed with DVD ripping in mind, it's now able to handle Blu-ray files amongst other tricks. We're not even going to start trying to go into the settings on this bad boy here, but we will point out that it has a one-click mode. Drag and drop a file you want to re-encode on to it, and select "One Click." Then, in the dialog that appears, click "Config" in the "Output" section.

You may want to select "Keep Input Resolution," otherwise choose a standard 1280 or 1920 width. Use the encoder to select x265, and "Config" to adjust the bitrate and number of passes. OK everything, and when you click "Queue," off it goes to do its thing!

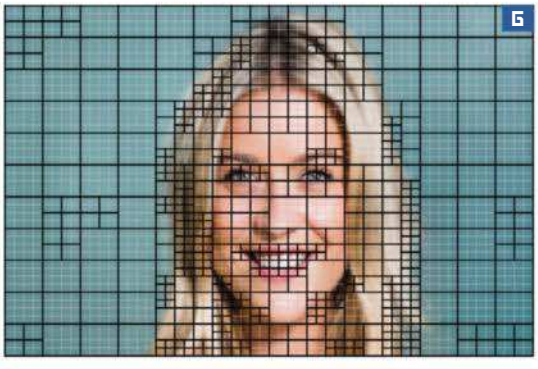


MPEG-4 Part 10—aka MPEG-4 Advanced Video Coding (AVC)—was formed.

Work started on AVC in 1998, and the first ratification appeared in 2003, 10 years after MPEG-1 began development in 1988, and its ratification in 1993. As you can imagine, some serious enhancements were implemented, taking advantage of the vast increases in processor speeds and system resources to both encoding systems and decoding devices, alongside enhancements to displays. We've gone from Video CD days to Full HD Blu-ray in just a couple of codecs.

We're not going to go into the depth of detail we've used for the various aspects of MPEG-1, partly as some are refinements on the basic techniques we've looked at, and largely as the complexity of implementation is so much greater, and we're running out of room!

To kick off, the I-frame prediction was vastly improved by increasing its complexity. The major move was variable block size for motion compensation in the macroblocks, from 16x16 down to 4x4, and any variation in between, such as 8x16 or 8x4 [Image G]. Multiple motion vectors per macroblock and available reference frames were increased to 16, with a buffering requirement of four or five versus just one or two previously. Motion compensation works on a quarter-pixel precision. A built-in deblocking filter helps to eliminate those 16x16 artifacts.



Variable-sized macroblocks in H.264 onward enable compression to be better targeted.

This is just a tiny portion of the improvements—for instance, there's a whole section on loss resilience to improve performance with corrupt data streams, plus enhanced protocol compression, lossless features, and feature-specific options to enhance black and white footage, visual transitions, or fades.

MPEG-5: PATENT WARS

As with the previous generation, a core design target for H.265—aka High Efficiency Video Coding (HEVC)—was to attain the same level of picture quality as H.264, but at half the bitrate [Image H]. Subjective testing rates it able to achieve at least a 56 percent reduction in bitrates at 720p, which increases to 64 percent at 2160p. Mission accomplished!

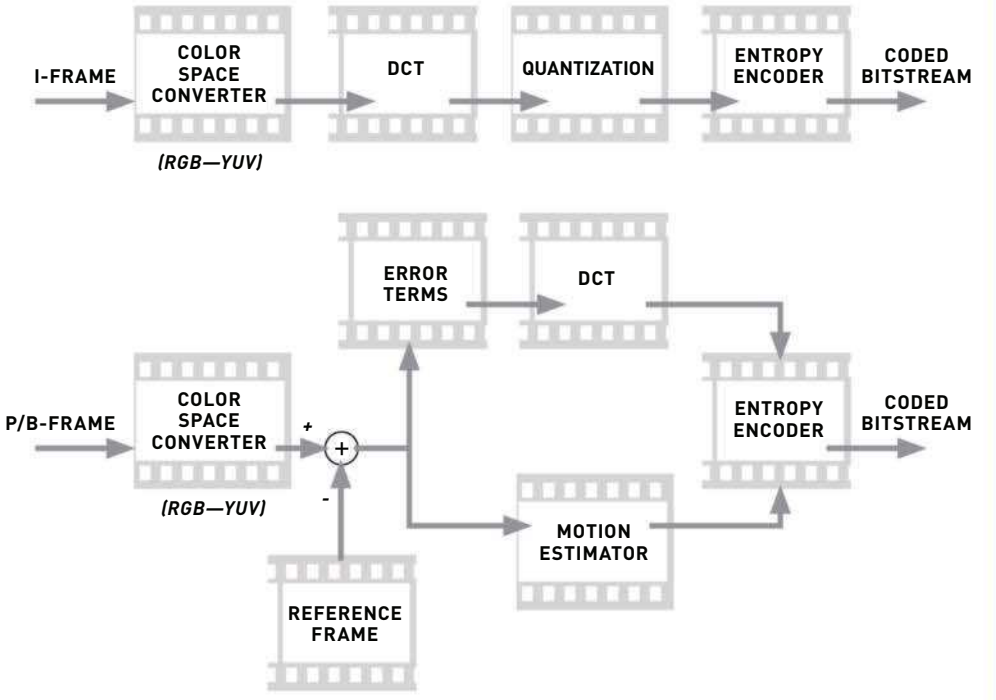
So, what's changed? To start with, fixed 16x16 macroblocks are out, and in their place are coding tree blocks (CTB). These can be 64x64, 32x32, or 16x16 pixels. A CTB can be then subdivided recursively into coding unit (CU) blocks, from 32x32 in size down to 8x8, stored as a "quadtree," as each CU subdivision is a quad of smaller squares.

Each CU is recursively split into transform units (TU), that again can be 32x32 down to 4x4, which are processed with DCT. On top of this, the alternative and more efficient discrete sine transform (DST) is used on 4x4 blocks. This flexibility and an increase in accuracy improves H.265's efficiency enormously.

The H.265 codec takes the chance to overhaul motion vectors in a big

F

MPEG2 H.262 (Simplified)



way, and it starts with prediction units (PU)—yes, everything's a unit! A CU can be split into one of eight PU types: the whole unit, half either horizontally or vertically, quartered, or a quarter strip at the top/bottom or on the left/right. We'll skip intra-prediction (in-frame) that's used to improve "flat" areas, but we will say that HEVC has 35 modes, versus the nine of H.264.

The real muscle is with the inter prediction motion vector system. It still has two reference lists with 16 entries each, but it can buffer eight pictures that can include the same frame multiple times for weighted predictions. There are improved motion compensation filters on both the luma and chrome channels, and an optimized deblocking filter that can be processed in parallel.

Finally, H.265 has been designed with multithreaded processing in mind for modern systems. The CTB design produces a grid of independent decodable blocks.

We're done. Phew! We've gained a lot of respect for codec designers and the people who have to implement these standards in smartphones and TVs. It's mind-boggling stuff, yet it all just works.

You can see the increase in complexity of the most recent H.265 model compared to MPEG H.262.

The abilities of x265 shine through over H.264 at lower bitrates.

H

©X265.COM

NEXT-GEN HEVC

Codec designers have done a staggering job of reducing bitrates whilst improving image quality, and not drastically increasing decode complexity. A less palatable aspect of the codec world is software patents, which impose licenses.

Licenses are fine, if fair, but the word on the street (http://bit.ly/MPC154hevc) is there was a marked increase for HEVC, which ensured the industry started looking for alternatives.

Google, with its vlog platform YouTube, has an obvious interest in not paying licenses for its growing user base. It bought in its VP8 codec tech, and now uses the H.265 equivalent but royalty-free VP9 for YouTube streaming. Netflix, which was heavily using H.264 AVC, switched to VP9 for compatible devices.

So, you can understand why the Alliance for Open Media (http://aomedia.org) was formed by Google, Mozilla, Microsoft, Netflix, Amazon, Intel, AMD, ARM, and Nvidia. AV1 is the codec it has been developing, released at the end of March 2018. Tests by Netflix show a rough 25 percent bitrate reduction over HEVC and VP9, but encoding is up to 10 times as complex, and a Moscow State University project revealed an unoptimized encoder was up to 3,500 times slower. A big hurdle for AV1 is hardware support; none is due until the end of 2019.

The HEVC people aren't sitting still—a new Joint Video Exploration Team has been formed to work on a next-gen codec for late 2020. It'll be up to 50 percent more efficient, and support next-gen display tech.

The future of encoders is open-source and free.

PC GAMER Club

BECOME A MEMBER **TODAY**

FROM $4.99 PER MONTH

Explore THE Legend

Join our quest and become a Legendary member to unlock these amazing benefits and more...

Digital subscription to the magazine

A monthly Steam key from Fanatical.com

Exclusive PCG-themed in-game items

Priority access to alpha/ beta codes

Join our private Discord community

SIGN UP ONLINE AT CLUB.PCGAMER.COM

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH

TASK VIEW TIMELINE

Task view has been around for a good while now, but the latest update to Windows has added a really neat and convenient feature in the form of a timeline view. Need to quickly access a program that you were using yesterday? Or even 20 days ago? Easy! Simply hit the Windows key and Tab, scroll down, and wham! It shows you all the programs and files you opened way back when.

MAKE – USE – CREATE

58 Emulate the Atari ST on your Raspberry Pi

66 Design your own esports team logo in Photoshop

68 Step-by-step guide to building a Phanteks-powered RGB beauty

ZAK STOREY
DEPUTY EDITOR

I AM SPENT

I am a broken human being. Last issue ruined me. Seriously—I'm writing this three days after deadline, while trying to nurse a horrific headache, and sipping on a cup of freshly brewed AeroPress-powered coffee. It was a tough one, that's for sure.

Yet, after spending most of last week fighting that awesome rig, getting it ready in time for the final shoot, and practically hating it by the end, I've had nothing but thoughts about how to make it better over the past weekend. Whether it's slight adjustments to tubing runs, or adding another reservoir in the rear to allow for easier loop filling, my brain's practically on fire with ideas and tweaks about how to make it one of the cleanest-looking ITX builds out there (despite the fact I've not even looked at it since Friday).

In a way, that's the scariest part of our passion, I guess. No matter what level your builds are at, or how much you've spent on them, it's never enough. There's always something else you can buy, some other way you can get more performance out of your system, or another tweak that will tidy it just a bit to make it look a little smarter. From build to desktop, hardware to software, there's always something to do. That's what makes PC building such an expensive hobby.

That said, judging from all my other hobbies and interests, that seems to be a theme. Hmm, maybe it's just me.... Time for another coffee, I think.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

OnePlus 6

We lift the back in trepidation, waiting for the familiar tug of a fingerprint sensor cable.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
To learn more, visit www.ifixit.com.

Having removed all the connectors tethering the motherboard to the phone, we slide it free.

BACKGROUND

OnePlus adds one more to its arithmetic-themed line of smartphones. The OnePlus 6 looks pretty good on paper, but how will these fancy specs add up on the teardown table?

MAJOR TECH SPECS

- 6.28-inch Samsung-made AMOLED display with 2280x1080 resolution (402 ppi), and 2.5D Gorilla Glass 5
- Octa-core, 64-bit Qualcomm Snapdragon 845 processor with 6 GB or 8 GB LPDDR4X RAM
- Dual main camera with 16MP (*f*/1.7 with OIS) and 20MP (*f*/1.7) modules; 16MP (*f*/2.0) selfie camera
- 64GB, 128GB, or 256GB built-in storage
- USB Type-C and 3.5 mm audio ports
- OxygenOS based on Android Oreo 8.1

KEY FINDINGS

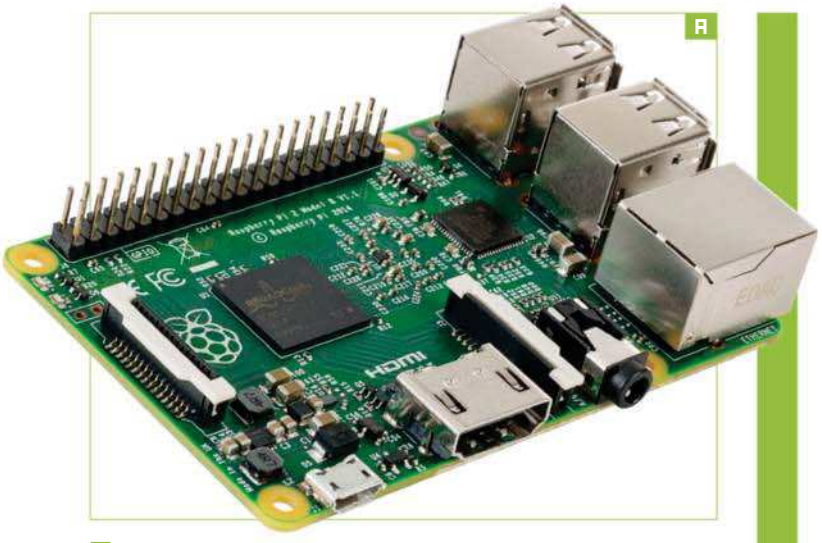
- An Android phone with a glass back? Thankfully, we've seen this before. The heat gun softens things up, and the iSclack and opening pick take care of the rest. The OnePlus 6 comes with a fingerprint sensor cable long enough to remove the back completely without worrying about tearing the cable.
- We pop off a nice red bracket to free that lengthy fingerprint sensor cable, and spy the NFC antenna. Prior OnePlus antennas did just fine without a glass back (which isn't even for wireless charging), so this glass seems to be just for looks. The friendly green tab on the accessible battery translates to "Pull up and out to remove the battery," not "Battery is not removable," as is written in the corner.
- Nine Phillips screws bite the dust and the plastic antenna frame doesn't budge. But a secret tenth screw behind a liquid damage indicator grants access. Under the plastic midframe, we get up-close and personal with the oversized slider mechanism. The button moves a hefty metal plunger, which flips a mechanical switch soldered to the motherboard.
- There are silicone seals around all the flex cable sockets—as found on the OnePlus 5, and every iPhone since the 6s. At the other end, under the loudspeaker assembly, we find more gaskets around the speaker grille, USB Type-C port, and modular headphone jack. Good to see OnePlus go for gaskets over goo, making disassembly and reassembly a snap.
- Although a dual rear camera setup first emerged on the OnePlus 5, this OnePlus includes OIS—a feature we haven't seen since the OnePlus 3T. Coupled with the new IMX519 sensor from Sony, this is a significant step up. Alongside it resides the 20MP Sony IMX 376K sensor, returning from the earlier OnePlus 5T. The selfie cam gets the 16MP IMX 371, which has been in circulation since the OnePlus 5 days.
- Returning to the bottom edge, we flip out a daughterboard and survey what's left in the chassis. The OLED panel is firmly glued in place; it probably won't come out undamaged. You'll likely only be removing a broken display, of course, but the procedure for doing so sure isn't repair-friendly.
- Repairability score: 5 out of 10 (10 is easiest to repair). The battery is only lightly adhered in place, plus there's a convenient pull tab. Many components are modular and can be individually replaced. All the threaded fasteners are standard Phillips. Display replacement is not prioritized in the design and will take a lot of work. Front and back glass means twice the risk of cracks. The primary access point for all repairs is heavily glued in place.

Emulate the Atari ST on Your Raspberry Pi

YOU'LL NEED THIS

RASPBERRY PI
The credit-card sized PC costs as little as $35.

YOU'LL ALMOST CERTAINLY REMEMBER the late '80s, when the eight-bit computing revolution gradually gave way to the rise of 16-bit machines. Atari and Commodore stood at the forefront of this revolution, with the Amiga eventually winning out. But for a while, during the late '80s and early '90s, the Atari ST ran it close. And thanks to the brilliant Hatari (http://hatari.tuxfamily.org), you can now resurrect the ST (and its successors) on your Raspberry Pi. –NICK PEERS



1 FIRST STEPS

You need a desktop environment to run Hatari—we're using Raspbian PIXEL. The latest version of Hatari uses SDL2 to render graphics, so you need to enable the OpenGL driver, noting that it's still experimental, and may be slightly unstable. It also means Hatari requires a Pi 2 [**Image A**] or better to run optimally.

» To enable the driver, open a Terminal window, type `sudo raspi-config` and hit Enter. Select "Advanced Options → GL Driver → GL (Full KMS) OpenGL Desktop Drive with Full KMS." Reboot when prompted.

» From here, installation is simple: Open "Pi → Preferences → Add/Remove Software," type "hatari" into the Search box, and you'll see one hit—select this, and click "OK" to install it. Once installed, open the "Pi → Games" menu, where you'll see two entries: "Hatari" and "Hatari UI." Choose the former option, where you'll immediately come across a message about not being able to load a TOS file.

» TOS is the Atari's operating system, and comes in a range of revisions and versions, depending on which 16-bit Atari machine you're trying to emulate. Technically, you should supply this yourself, but thankfully the hard work of obtaining any version of TOS has been done for you.

» Before proceeding, a quick note about legalities: When running emulator software, it's assumed in most cases that you own the original computer as well as any software you play on it. From a legal standpoint, you should really honor this, but practically speaking, there's nothing but your conscience preventing you from running whatever you like, even if it's no longer buried away in your basement somewhere.

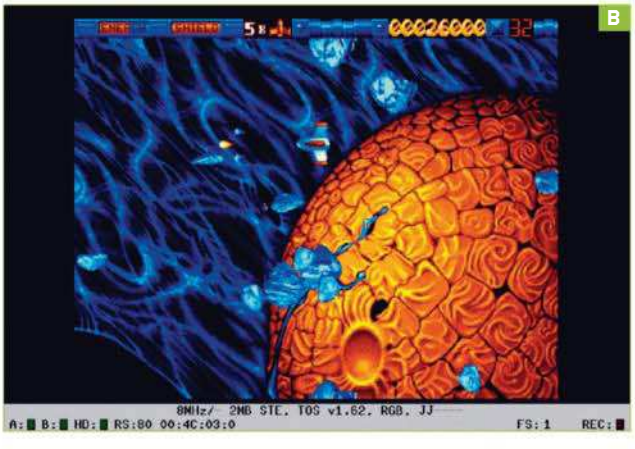
2 INSTALL TOS

Let's begin by obtaining TOS for Hatari. Open your web browser and head to www.atariworld.org/tos-rom, where you'll find every single version of TOS, from the original 1.0 release up to TOS 4.92 for the Atari Falcon. Which one do you need? It depends on what you're planning to emulate. The original STFM model, which covers most bases, runs best on TOS 1.4, but you may want to download TOS 1.02 for some older games. Those emulating the STE—which was capable of better graphics [**Image B**]—want TOS 1.62, while TOS 2.06 (both STFM and STE) is a good choice when copying lots of files via the ST's GEM desktop.

» A word to the wise: The TOS 2.06 ROM file has the wrong permissions assigned to it—you need to right-click the IMG file after extracting it, and choose "Properties → Permissions." Make sure "View Content" is set to "Anyone," and "Change Content" is set to "Only Owner," before clicking "OK," and copying the file across.

» If you're determined to stay on the right side of the law, and have no Atari gathering dust in the attic, try EmuTOS instead (http://emutos.sourceforge.net/en). It's a free version of TOS that can run on physical computers via floppy disk, as well as your new Hatari emulator, but note that it'll be hit and miss what games and software you'll be able to run on it.

» When it comes to downloading your version of TOS, choose the "English US" link. A zip file is saved to your Downloads folder, ready for use shortly. You now have all the elements that you need to start configuring Hatari itself. The four-step walkthrough on page 61 reveals the key steps you need to follow.



3 DOWNLOAD FLOPPY DISK IMAGES

As things stand, your Hatari setup is now a fully functional Atari machine—the only thing missing is software. Most games come on floppy disks, and once again, the painstaking process of converting ST floppy disks into image files, recognizable by your Pi, has been done by others. All you need to do is locate and download these images, which come in MSA, ST, or STX format.

›› There is a wide range of sites offering images—Google "Atari ST ROMs" for a long list. If you can cope with the fact that it's French (Chromium will offer to translate the pages for you), we like www.planetemu.net/roms/atari-st-games-st in particular. You'll find some games are listed several times, based on who's submitted the images—try one, and then download another if it doesn't work.

›› As with ROMs, floppy disk images are downloaded in zip format, so you need to extract them first. Then you're presented with files in .ST or .STX format (associated with Hatari, so you see a nice floppy ST icon to help identify them). These can be stored anywhere on your hard drive, but we recommend setting up a dedicated folder—"atarist," say—inside your home folder for easy access.

4 PLAY ST GAMES

There are two ways to load floppy disks into Hatari. The simplest thing to do is simply browse to the folder containing your disk images, and double-click the .ST or .STX file. Hatari launches using the configuration you've saved under hatari.cfg, and then—after a pause that can be quite lengthy—the familiar green ST desktop appears, or the game automatically loads. Double-click the A drive icon if necessary, followed by the game file to start loading it.

›› If you plan to play a game that comes on two floppy disks, it's easier to start things off inside Hatari itself: Press F12 to bring up the configuration screen [Image C], and click "Floppy Disks." Click "Browse" next to "Drive A" to load disk one into drive A, then repeat with "Drive B" for disk two. Leave "Auto Insert B" selected, then click "Return to Main Menu," followed by "OK."

›› Keep an eye on the status bar at the bottom of the screen, which should hopefully indicate the floppy disk is still loading. It can be a slow process; one way to speed up load times is to tick "Fast Floppy Access" under "Floppy disks" in Hatari's configuration. Another is to switch to Fast Forward mode—press AltGr-X to speed things up slightly. Press it again to return to normal speed. Once done, the game's main screen should appear, and it's then a case of navigating it with your mouse, keyboard, or game controller.

›› To set up the latter, press F12, and click "Joysticks." From here, you can select whether to disable the port, use a "real" joystick, or define the keys used to simulate the joystick, namely up, down, left, right, and fire [Image D]. Up to four ports can be configured—two regular ST joysticks, plus two additional STE-only joypads.

C

›› When it comes to using a real joystick, any game controller that's plugged in and recognized by your Raspberry Pi should be immediately visible—our wired PC/PS3 Gioteck controller was detected instantly, for example. As you'll have seen when defining keys to simulate a joystick, ST joysticks were basic, and only supported four directions of movement and one fire button—use the analog stick and the top fire button to emulate the joystick, while the secondary fire button emulates the space bar key.

5 CREATE YOUR OWN BLANK FLOPPIES

If you're trying software that appeared on magazine covermount disks, chances are that it was compressed to enable more content to be placed on the disk. You'll need to extract it to a separate "disk"—we'll cover hard drives in a moment, but if you simply want to run the software from its own virtual floppy image, click "Create Blank Image" on the "Floppy Disks" configuration screen. Leave the default settings—80 tracks, nine sectors, and two sides—as they are, give your floppy a label, then click "Create."

›› Next, choose where to save the floppy—your default folder is best—and again name it for the game you plan to copy to it. Click "OK," then "Back," followed by "Drive B:" to insert it into drive B. You can now either copy the compressed file across before double-clicking it to unpack the game, or use the covermount's own program to extract the files to the new disk. Be warned: It's slow.

6 BEYOND THE BASICS

As things stand, you now have a fully working Atari machine, running at decent speed. If all you're

COMPATIBILITY ISSUES

If you're lucky, you'll play a number of games before coming across one that doesn't work. Start by visiting http://bit.ly/hatari-compat for a non-exhaustive list of ST programs that are known to cause problems. Failing that, check the site you downloaded the disk from to see if there's any specific configuration you should use. If you're running an older game, try using ST mode with TOS 1.02 for compatibility purposes.

Avoid allocating more than 2MB of RAM to your virtual ST, because timing issues can cause problems, too—1MB should be ample for most games.

Some games and demos are very particular about floppy emulation—press F12, click "Floppy Disks," and uncheck "Fast Floppy Access" to see if they're now able to load successfully. Other settings to tweak include unchecking "Boot Faster" and "Patch Timer-D" under "System." If there's screen corruption, also try different "Video Timing" settings.

Switching settings can be awkward, but Hatari makes it possible to save multiple configuration files by changing the name of the .cfg file, enabling you to set up multiple setups (say STFM, STE, and Falcon), and switch between them. Hatari loads the hatari.cfg file by default on startup, but you can quickly switch by pressing F12 followed by "Load Config."

D

interested in is reliving past glories, you should have all you need to play games on your Atari. But you can push the envelope further....

» First, look beyond the ST as a mere gaming machine—it was also renowned as a music-making tool, and as the games market waned, major apps continued to be developed, from video editing and word processing to desktop publishing. Visit www.planetemu.net/machine/atari-st, where you'll find a wider range of titles, including demos, magazine coverdisks, and public domain releases.

» As the number of titles grows, you may get tired of having to press F12 to swap floppy disks around. Use AltGr-D to swap disks, followed by AltGr-R to perform a warm reset, or AltGr-C for a cold reset. Alternatively, why not connect a virtual hard disk to your ST? The boxout below reveals the simplest way to add a single 80MB ACSI hard disk. You can duplicate this blank image file to create multiple hard disks, but you can only connect one at a time.

» Another option is GEMDOS, which enables you to mount a folder on your Raspberry Pi's storage as a virtual drive, making it easier to copy files directly to the drive from your Pi storage. Note, however, that you'll either need a dedicated hard disk driver, or you'll have to access the drive using EmuTOS, which supports GEMDOS natively.

CREATE A VIRTUAL HARD DRIVE

Floppy disks are slow. Attach a virtual hard drive, and loading times are quicker, and you can switch between programs without having to swap out disks. Hatari supports three type of emulated hard drives: ACSI, IDE, and GEMDOS. Of these, ACSI is the most compatible option, and works with all versions of TOS from 1.02 up.

ACSI emulated drives exist physically as an IMG file, and can be awkward to set up, plus they require drivers placed on the virtual hard disk to work correctly. Thankfully, Hatari provides you with an empty 80MB hard drive image, which you can download from **https://hatari.tuxfamily.org/hd80mb.image.gz**. Extract the hd80mb.image file to a suitable folder, then open Hatari's configuration, select "Hard Disks," and click "Browse" next to "ACSI HD Image" to select the file.

Reboot your ST, and you'll see a new drive C appear, to which you can copy files. Note that many commercial games refuse to run from hard disk. For those that do (such as *Civilization)*, just keep your games in separate folders, and make sure you save your configuration, so the hard disk is always accessible whenever you start your virtual ST.

E

» If you find yourself getting into an old game or two, you may want to know how to save your progress. If the game itself has a save option, you could always create a blank floppy image, as outlined earlier, and insert it into drive B. Alternatively, you could use Hatari's own memory snapshots feature, which are obviously quicker.

» Start by pressing F12 and selecting "Memory." Click "Save," type a suitably descriptive filename (with the all-important .sav extension), and click "OK." Return to your game, pressing AltGr-K at any time to update the saved file with your latest progress, or AltGr-l to reload your last saved state.

» You can also snap screenshots at any point—press AltGr-G to take a screen grab in PNG format. Press AltGr-A to record an AVI movie (you'll see the "Rec" button turn red in the Hatari status bar), and press it again to stop recording. Finally, press AltGr-Y to start and stop recording your ST's sound. All recorded material can be found in your home folder.

» By default, your Atari machine emulates a colour RGB monitor, which enables you to switch between low and medium resolutions. To run high-resolution programs, such as DTP software, press F12, click "Atari Screen," then select "Mono" [**Image E**].

7 MIDI FOR MUSICIANS

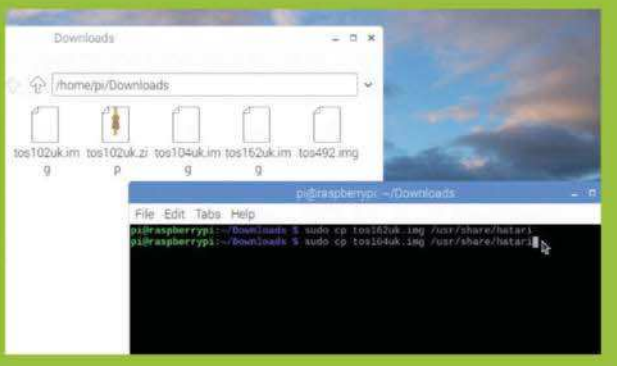
The ST was a big draw for musicians, with its built-in MIDI ports, and was used by major artists, including the likes of Queen for *The Miracle*. If you have a USB-to-MIDI cable, you can hook up a MIDI keyboard to use with the likes of Cubase [**Image F**].

» First, you need to verify your cable has been detected by Raspbian. Open a Terminal window and type:

```
$ lsusb
```

F

CONFIGURE YOUR VIRTUAL ATARI ST



1. COPY TOS FILES

Open File Manager. Double-click the downloaded TOS zip file to open it in Archive Manager, then drag the .img file into your Downloads folder. Once done, press F4 to open a Terminal window pointing to the Downloads folder, and type the following (substitute `tos102uk.img` with the image file):

```
$ sudo cp tos102uk.img /usr/share/hatari
```

2. SET SYSTEM TYPE

Now open the Pi menu and select "Games → Hatari." Click "OK" at the "Could not load TOS file" screen. When the main menu appears, click "System." By default, Hatari is configured to emulate the STFM, but you can select a different Atari machine from the list. Check "Boot faster by patching TOS & sysvars," regardless of which machine you choose, to speed up loading times slightly.

3. SELECT ROM AND RAM

Return to the main menu and click "ROM." Click "Browse" to select the TOS image you copied across in step one—make sure it matches the Atari machine you're emulating. Click "Back to main menu" again, then click "RAM." By default, 1MB is allocated, which is sufficient for gaming—drop this to 512K for some older games if they refuse to load.

4. SELECT FLOPPY DISK AND SAVE CONFIGURATION

Now click "Floppy Disks" followed by "Browse" next to "Default Floppy Images Directory" to select the folder you've stored your disk images in. Check "Fast Floppy Access" to help speed up loading times, but note that some disks may not work (in which case, unchecking this may help). Click "Back to main menu" followed by "Save config" to save your setup.

» You should see your MIDI adapter listed. Now type the following, which should verify at least one MIDI port is available:

```
$ aplaymidi -l
```

» If they're available, open Hatari, press F12, then click "Devices." Click the two "Browse" buttons under "Enable MIDI Emulation," and point them to whichever MIDI entry appears under /dev/snd. Check "Enable MIDI Emulation," and restart your virtual ST.

» If you don't have a MIDI device, try a software MIDI synthesizer. First, install Virtual MIDI Piano Keyboard (search "Pi → Preferences → Add/Remove Programs" for "vmpk"). Next, launch QSynth from "Pi → Sound & Video," followed by VMPK. In VMPK, select "Edit → Connections," click the "Output MIDI" connection, and choose "FLUID Synth" to connect the two. Hit the virtual keys, and you should hear sound to verify it's working. Open Terminal and type:

```
$ sudo modprobe snd-virmidi
$ aconnect -i -o
```

» Make a note of the client numbers, and then type the following:

```
$ aconnect <sender> <receiver>
```

» Substitute <sender> with the client number of VMPK Output, and <receiver> with the client number of the first Virtual Raw MIDI port. Now repeat the command, but this time substituting <sender> with the Virtual Raw MIDI port, and <receiver> with the Synth Input port—like this, for example:

```
$ aconnect 128 28
$ aconnect 28 130
```

» Now open Hatari, press F12, click "Devices," then point it toward the correct connection. Check "Enable MIDI Emulation," and you should be able to use your virtual synthesizer to input music into sequencing software like Cubase, while listening back through QSynth. Job done!

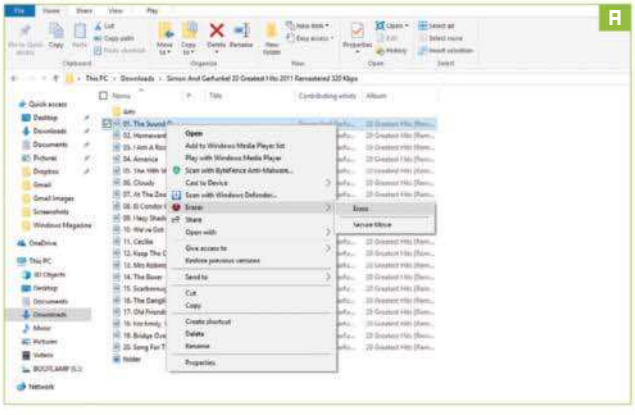
Securely Delete Data With Eraser

YOU'LL NEED THIS

ERASER
Download this free tool from http://eraser.heidi.ie.

THE REVELATIONS BY EDWARD SNOWDEN about NSA spying activities and the recent introduction of stringent data protection laws in the EU have left everyone, from privacy-minded individuals to big businesses, worried about data security. As any power user knows, any files that are nominally "deleted" by Windows usually remain on your hard drive. The OS simply changes a few bits in the file header to tell the system the data is no longer required. As useful as this is for legitimate users who may have deleted data by accident, bad actors, such as hackers, can use freely downloadable digital forensic tools to recover your files in seconds.

Eraser, which comes to us courtesy of Heidi Computers in Wicklow, Ireland, seeks to restore the balance. This free utility works by repeatedly overwriting every bit of data in files or folders you select to delete it securely. Eraser is highly customizable: You can choose your own erasure method, such as seven passes of pseudo-random data, and can even automate tasks, such as overwriting free space on your hard drive. While Eraser isn't completely effective when it comes to flash memory (see boxout, below-right) and more advanced forensic techniques, you can gain some peace of mind knowing you're using the very best erasure methods available. **–NATE DRAKE**


A

1 SET UP ERASER

Open your web browser of choice and navigate to https://eraser.heidi.ie/download/. Click the "Download" tab and then choose the most recent stable version of Eraser, which is at the top of the list. Your browser is now redirected to Source Forge, which hosts the installation files. Windows 10 displays a security alert at this stage. Click "Yes" to begin installation. The setup wizard first tries to install the .NET Framework 4 on your machine. If this is already installed on your version of Windows, you may see a system prompt. Click "Close" to proceed. Select "Next" on the welcome screen, and check "I accept the terms in the license agreement."

›› The wizard now asks you to choose an installation type. A "Typical" install incorporates of all Eraser's main features. Choose a "Complete" installation if you want to include additional functions, such as shell extensions. Click the "Install" button once you've chosen the type of installation you want, then click "Finish" to close the setup wizard.

2 ERASE DATA

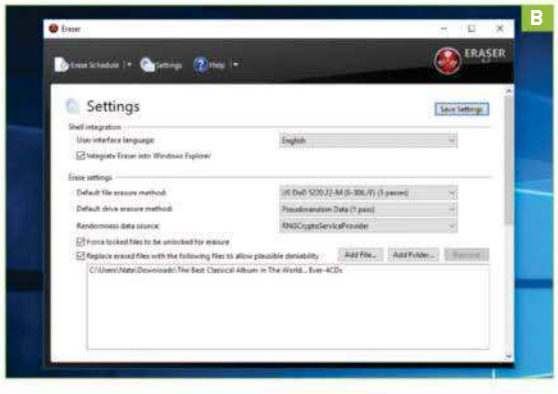
If you chose to install shell extensions, you can access Eraser with just a few clicks of your mouse. Open the File Explorer, and navigate to the file or folder you wish to securely delete. Right-click to open the context menu, and move your mouse to "Eraser," then choose "Erase" [Image A]. The first time you do this in Windows 10, you'll need to click "Yes" to grant Eraser permission to make changes.

›› Eraser asks you to confirm before proceeding. Remember that any data removed will not be stored in the Recycle Bin prior to deletion, so carefully check you have the right information before clicking "Yes." Eraser displays a notification reading "Task Completed" once your data has been securely erased. This may take some time, depending on Eraser's configuration.

3 CONFIGURE ERASER SETTINGS

By default, Eraser uses the Gutmann method to delete files, which involves overwriting data 35 times. While this is ultra-secure, it's usually overkill for most users, and can take hours or days to complete for larger files. Fortunately, Eraser supports a number of different methods to remove data.

›› Launch Eraser and click "Settings." Find the "Erase Settings" section, and select the drop-down menu marked "Default file erasure method." The US DoD (Department of Defense) standards for erasing data involve either three or seven passes, depending on the sensitivity of the information. While theoretically not as secure as the Gutmann method, they are much more efficient. Click "Save Settings" at the top-right to confirm changes.



B

4 PLAUSIBLE DENIABILITY

While deleting files with Eraser makes them very difficult to recover, anyone with access to your hard drive can potentially view the clusters of pseudo-random data on your drive, and realize that you have something to hide. Mercifully, Eraser supports "plausible deniability." This works by placing a harmless-looking file, such as an MP3, over erased data, making it much more difficult to tell where sensitive files were located previously. To do this, first choose a folder to use for decoy files, such as a music album. Open Erasure's settings, and check "Replace erased files with the following files to allow plausible deniability." Next, click "Add folder," and select your chosen files [**Image B**]. Click "Save Settings" once you are done.

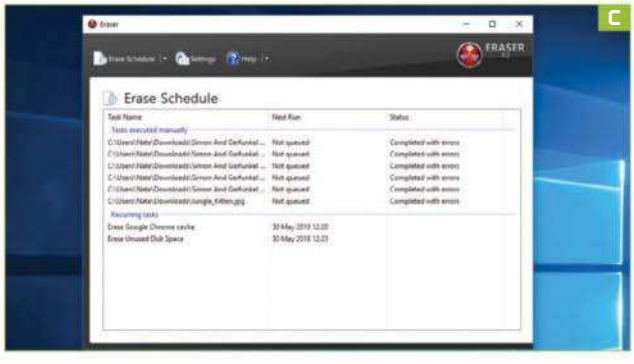
›› Note that with the advent of file journaling and SSDs, plausible deniability has become difficult to achieve in practice. We strongly recommend using full-drive encryption (see "SSDs: A Special Case" below).

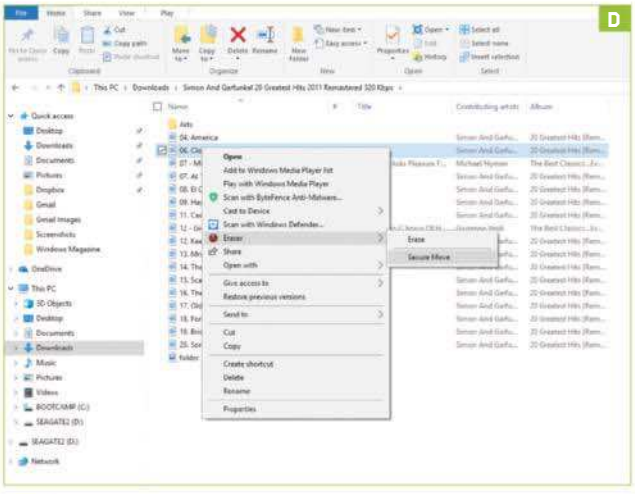
5 SCHEDULING TASKS

Eraser supports automated deletion of data [**Image C**]. This is useful for removing files in obscure locations, such your web browser's cache.

›› Click "Erase Schedule," then select "New Task." Under "Task Properties," first enter a meaningful name in the name field, such as "Erase Google Chrome cache." Choose "Recurring" under "Task Type," then click "Add Data." In the new window, select "Target type"—for example, "files in a folder"—and choose an erasure method, such as "Gutmann." Use "Browse" to enter the file or folder path, then click "OK" to confirm. Finally, click the "Schedule" tab to determine the time and frequency of your new task, such as @ 13.30 daily. Click "OK" to set your new scheduled task.

›› You can also use this feature to regularly erase free space on your hard drive. Simply choose "Unused disk space" in the "Add Data" section. You can also manually overwrite free space on any drive by right-clicking it in File Explorer, and choosing "Eraser → Erase Unused Space."





6 SECURE MOVE

Eraser also incorporates a handy feature for moving files and folders securely. It does this by creating a copy of your data in virtual memory, securely erasing the original, and copying the file or folder to a destination of your choice.

›› To make use of this feature, first open File Explorer and navigate to the file or folder you wish to move. Right-click to open the context menu, and choose "Eraser → Secure Move" [**Image D**]. Eraser automatically opens a prompt asking you to select the target destination, such as a USB drive. Navigate to this and click "OK." Eraser manages the copy process and securely removes data in the usual way.

›› By default, Eraser overwrites drives with one pass of pseudo-random data. If this isn't sufficient to abate your paranoia, access Eraser's settings, and choose a more secure method from the drop-down menu under "Default drive erasure method."

7 SECURELY ERASE RECYCLE BIN

If there's content on your PC that you've deleted previously, follow the steps outlined above to erase free space on your hard drive. If, however, the files and folders you want to remove are still in your Recycle Bin, Eraser can securely move these in place. Simply right-click the Recycle Bin and choose "Erase." If you've previously enabled the plausible deniability feature, note that Erasure doesn't place decoy files in the Recycle Bin. Be sure to use Eraser directly on sensitive data in future if you want to avoid scrutiny of your hard drive.

SSDS: A SPECIAL CASE

Solid-state drives and USB sticks use flash memory. While this works much faster than a magnetic hard drive, each sector can only be written to a finite number of times. For this reason, most solid-state devices employ "wear leveling" mechanisms, which spread data around the drive as evenly as possible. This means the drive lasts longer, but is a nightmare from a security perspective, as most wear leveling procedures interfere with the secure erasure of data. When it comes to flash memory, there is no way to be sure sensitive data is completely gone, no matter how many times a file or folder is overwritten.

Short of incinerating your SSD or giving it an honorable burial at sea, the only way to be certain your files are safe is to employ full-disk encryption, using a program such as VeraCrypt or Microsoft's own BitLocker. If an adversary attempts to recover data from an encrypted solid-state drive, they will find only fragments of encoded data, which are useless without the correct decryption key.

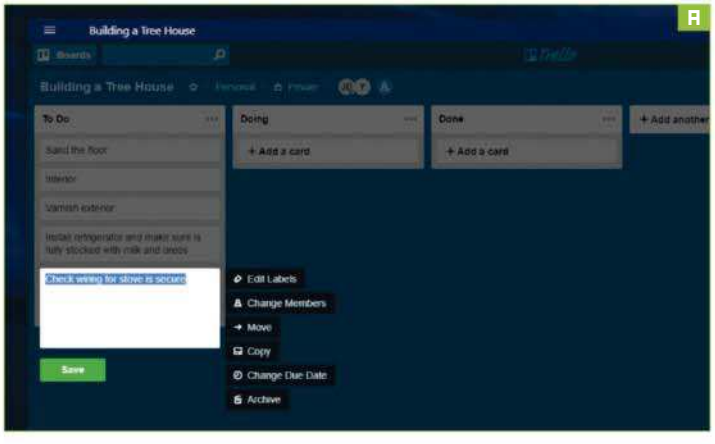
Manage a Major Project Using Trello

YOU'LL NEED THIS

TRELLO
You can grab this free app from the Microsoft Store.

FANS OF THRILLERS will know that every conspiracy theorist gives over a huge section of their living room wall to pictures, newspaper clippings, and various crazy schemes. In the real world, project managers can also quickly become daunted when managing a large project, even with the help of computers. Whether you're trying to find the second gunman or overseeing a complex construction project, Trello offers a crisp and elegant way to put your plans in motion. This free app helps you realize your goals through the use of simply laid-out "Boards," on to which you can place any number of virtual "cards" and lists, to record tasks to do and the resources you need. The dedicated Trello app is also available for mobile and syncs automatically, so you and other Board members can work together on projects in real time.

In this guide, you'll learn how to create a Trello account and invite other collaborators to do the same. You'll discover the basics behind creating your first project, as well as how to color-code and otherwise customize cards for the sake of efficiency. Trello can be enhanced even further by using "Power-Ups." You can use these to enable extra features, such as Calendar View. **–NATE DRAKE**



1 SET UP A TRELLO ACCOUNT

Open the Microsoft Store and search for "Trello." Click the name of the application to open its dedicated page. Make sure your system is running Windows 10 Version 14316.0 or later, and has at least 150MB of free disk space. If you are unsure which version you have, run Windows Update before proceeding. You can check the amount of free disk space under "System Information." While Trello shouldn't affect other files on your system, there's always a risk of instability when adding new programs. Be sure to save and close any open files, and run a full system backup before proceeding.

›› Click "Launch" when installation is complete. Trello now displays a dialog outlining its functions. Click "Continue" to proceed. Next, click "Sign Up" to create a Trello account. Click "Create New Account" to continue. Trello sends you a link via email to confirm your address. Enter your name, email address, and password in the corresponding fields.

2 CREATE YOUR FIRST BOARD

Trello's main dashboard now appears. At the center of the screen, you'll see a prompt saying, "What are you working on?" Click here to enter the name of your current project, then click "Create Your Board."

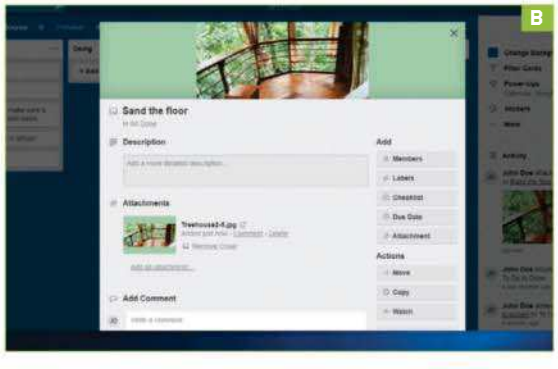
›› Your first order of business should be to decide whether this project is visible to others. You can make this visible to yourself only by selecting the "Personal" button on the top of the window, beside the title of your project.

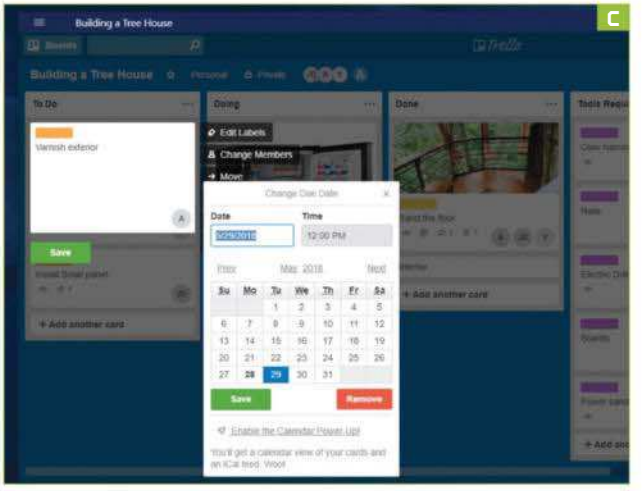
›› If this is a group project, you can add other people to your Board, even if they are not currently Trello members. Click the "+" button at the top-center of the screen, and enter the email address of your collaborator in the search box. Click "Send." Your contact receives an invitation to collaborate with you on this project. To make sure you and your chosen contacts can access project details, select "Private." You can find this beside the "Personal" button.

3 MANAGE TASKS

Trello breaks your project down into manageable chunks. You can create any number of cards under the "To Do" section on the left-hand side of the screen. To get started, click the "Add a Card" button, and enter the task in question—for example, "Sand the floor."

›› Once you have created the necessary cards, click the "Options" button on the top-right of the card to add more information. Use the comments field to add any further thoughts. The "Edit Labels" option is excellent for color-coding tasks. For instance, you can use the "Description" field under the "Sand the floor" task to remind yourself where the sander is. If you are finished with a card but the project is incomplete, choose "Archive" from this menu [Image A]. To view "Archived Items," select the "More" button on the right-hand side of the screen.





4 ADD ATTACHMENTS AND LISTS

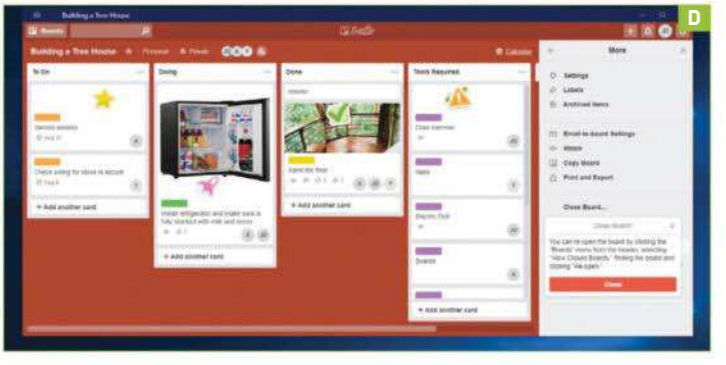
Trello also supports adding attachments [Image B], such as photographs or useful hyperlinks. You can add as many attachments as you wish. To do so, select the card and choose "Add Attachment." Click and drag on a task to move it to the "Doing" and "Done" lists. If your project is more nuanced than this, you can rename and/or create new lists. Lists are not only for keeping track of completed tasks; you can also add your own content—for example, to itemize the equipment you'll need to complete your project, such as power tools.

5 ASSIGN TASKS

For larger projects, you may prefer to assign tasks or lists to individual members. To do so, first make sure you've added members to your project using the "+" button in the center of the screen, as outlined previously. Next, click the "Edit" icon on your chosen card, and choose "Change Members." Trello now lists all your project members. Use your mouse to select one or more people, then click "Save" to assign the task to them. You can assign tasks to yourself in exactly the same way. Newly assigned tasks appear in the "Activity" center on the right-hand side of the screen for all members. You can also view past notifications by clicking the "Bell" icon on the top-right of the window.

6 SET DUE DATES

To set deadlines for tasks, click the "Edit" button on a card, and choose "Change Due Date." Trello displays a pop-up enabling you to choose a date and time [Image C]. The first time you do this, Trello also offers to enable the Calendar Power-Up, which activates Calendar View for your cards, which can integrate with iCal feeds. Once enabled, you can access Calendar View at the top-right of the window.



TRELLO POWER-UPS

You can hugely enhance your Trello experience by using "Power-Ups." These are software modules that improve the application's performance in some way. The Calendar View, for instance, exists thanks to a cleverly coded Power-Up.

Other useful Power-Ups include Slack, which enables you to communicate in real time with other Board members via the site's messaging platform. There are also Dropbox and Google Drive Power-Ups, which offer a simple way to attach larger files to cards. The Custom Fields Power-Up enables you to add special fields to cards, such as dates, numbers, checkboxes, and drop-down menus.

To start adding Power-Ups, click the corresponding button on the right-hand side of the window, and select the "Enable" button next to your chosen add-on. You can choose from a variety of categories, such as "Analytics and Reporting," by selecting the relevant tab. To deactivate a Power-Up, simply re-enter the menu, and click "Disable."

7 TRELLO TWEAKS

Trello is designed to be easy on the eye. If the default background isn't to your liking, simply click the "Menu" button at the right of the window, and select "Change Background."

›› To further simplify your project, you can also access "Stickers" from the same menu. This enables you to select from a variety of easily understandable symbols, such as a green check mark. Drag and drop these on to the cards and lists of your choice for easy recognition. If Trello's built-in collection of stickers falls short, consider purchasing a Trello Business Class subscription for $9.99 a month, which includes a much wider range of symbols.

8 EXPORT AND PRINT

If you're using Trello for work, your organization may require you to keep offline backups of your projects. Although the app is proprietary software, you can export projects in the universal JSON/CSV formats. To do this, click the "More" button on the right-hand side of the screen. Select "Print and Export," then click the button for your desired file format. You can also use this menu to print a hard copy of your project, by selecting the "Print" button. Once your project is complete, you can use the "More" menu to indicate this by choosing "Close Board" [Image D]. To view a closed board, click "Boards menu → View Closed Boards → Re-open."

Design Your Own Esports Team Logo

YOU'LL NEED THIS

PHOTOSHOP
Subscribe to various Adobe packages at www.adobe.com.

LOGO DESIGN IS A REAL ART. There are agencies across the world that will charge you seven figures to design not just a logo itself, but a whole system of interlocking pieces for your corporate identity, including possibly a bespoke font.

If you want something to be easily recognized while you're heading up the esports world rankings, however, it's perfectly possible to do it yourself. There are some rules, though—more like guidelines—such as making sure your logo has a memorable silhouette and is appropriate for the uses you have for it. Research other logos in the same market place to see what other people have come up with. Death metal band Party Cannon uses a friendly, colorful logo that couldn't be more different from those of other heavy bands, which are apparently created from piles of bone spiders. This means it stands out on posters, and will probably be remembered, but has the unfortunate effect of lowering the band's credibility in the eyes of casual onlookers.

Remember: You're not just designing, you're selling, too, and injecting a bit of humor into a logo goes a long way. Now let's look at what we can do in Photoshop. –IAN EVENDEN

1 NEW BEGINNINGS

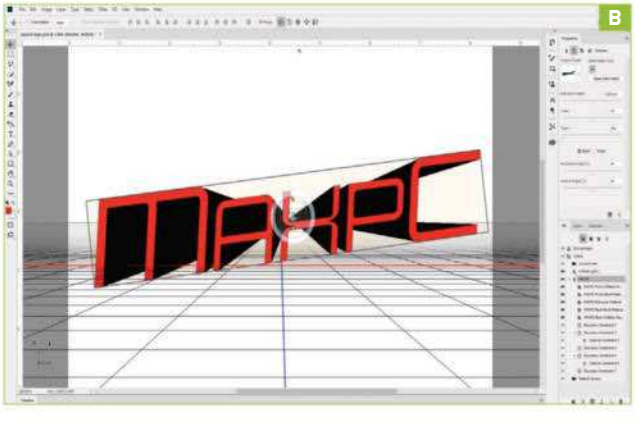
We're starting from scratch this time, rather than having a photo or two to work with, so open Photoshop, and go to "File → New." We've created a square document with 1,000 pixels per side, in RGB color, and at 300 ppi. This is fine for web work and most printing, but if you know you'll want to print the logo much larger, create a larger document, and scale up accordingly.

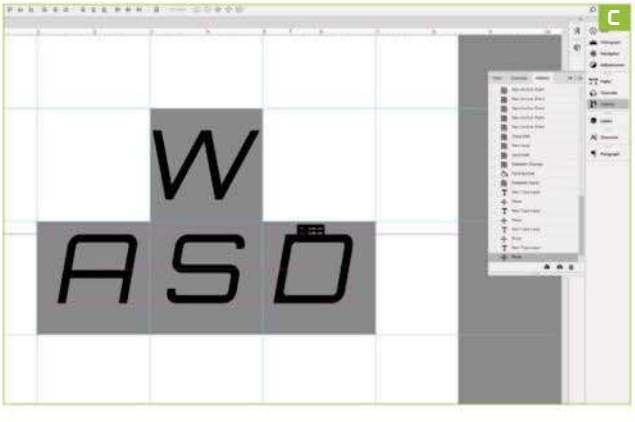
2 THE NAME GAME

We're going to start with the text, because the name of your esports team is the most important thing. Choose a font you like, and bang out the name, making it large enough to fill the center of the document. We can always shrink it down later if needs be. For a dynamic look, you can make the first and last letters of the name slightly larger than the others, by selecting them individually, and increasing the point size in the box at the top of the interface. Some fonts support alternate forms for some letters [**Image A**], which can make your logo look more interesting—select an individual letter, and any alternates appear on a little pop-up, or in the Glyphs palette from the Window menu. Be sure not to make it totally unreadable, though, as that would defeat the whole purpose of your logo.

3 MESS ABOUT WITH MESH

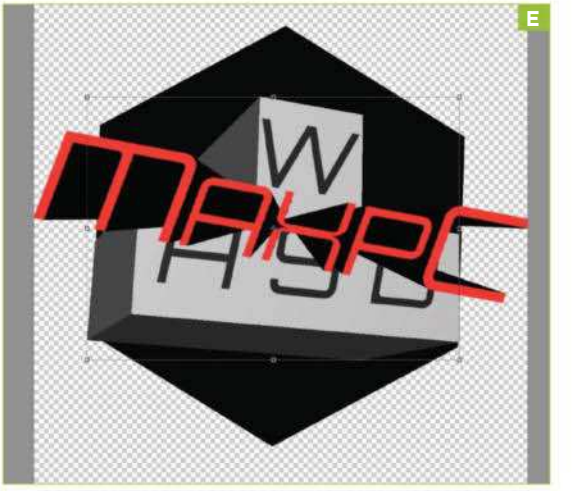
Making 3D text is easy in Photoshop CC. Understanding what you're doing while making it, though, it is rather more difficult. Photoshop's 3D interface is like an app to itself, but to create a simple 3D effect, select your text layer, then hit the "3D" button up on the options bar. It opens in Mesh mode, in which you can use the Move tool to move the text back and forth on the Z axis, but Deform mode is much more interesting [**Image B**]. You change between modes on the Properties palette, which opens to the right. Play about with the settings until you get something you like the look of. We went back into Mesh mode and turned off Cast Shadows, because it didn't look





THE 3D PANEL AND POSTCARDS

Photoshop CC includes all the 3D capabilities from the old CS6 Extended release, and builds on them. The app uses the name "postcard" for a 2D layer that's been converted to a plane in a 3D composition. 2D layers can be wrapped around 3D objects, such as cones or cubes, and a grayscale 2D layer can be used as a depth map for creating a 3D mesh. The 3D panel appears near Layers when you've got a 3D layer in your composition. It lists the meshes, materials, and lighting choices you've made for the 3D object, and enables you to tweak settings and options. You can turn the visibility of meshes or lights on and off in the same way you would a layer, by clicking the eye icon next to their entry in the 3D palette, and click them directly to edit them.



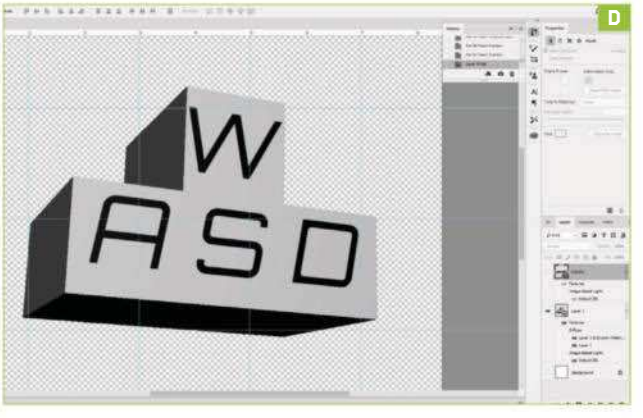
quite right on our logo. To exit the 3D workspace, use the workspace switcher at the top-right.

4 SHAPING UP NICELY

We're going to put a shape behind the text layer. We want to keep things reasonably simple, though, so threw out the idea of drawing a motherboard or graphics card outline, then filling in fans and edge connectors, shortly after we thought of it. A keyboard shape might work well, for those who don't mind nesting a whole lot of rectangles inside another rectangle, but we decided on an inverted-T WASD-key shape. To create this, we hid the existing text layer, and spaced out a grid of squares using guides dragged from the rulers, then used the Pen tool to draw the inverted-T, loaded the resulting path as a selection from the Paths palette, and used the Bucket to fill it with gray on a new layer. We used the Text tool to add the W, A, S, and D in the appropriate places [**Image C**], merged the text layers and the graphic layer together, then right-clicked the resulting layer in the Layers palette, and chose "New 3D Extrusion from Layer." Then we used Deform mode to rotate it slightly, making it clear it's 3D, and again turned off its shadow casting [**Image D**].

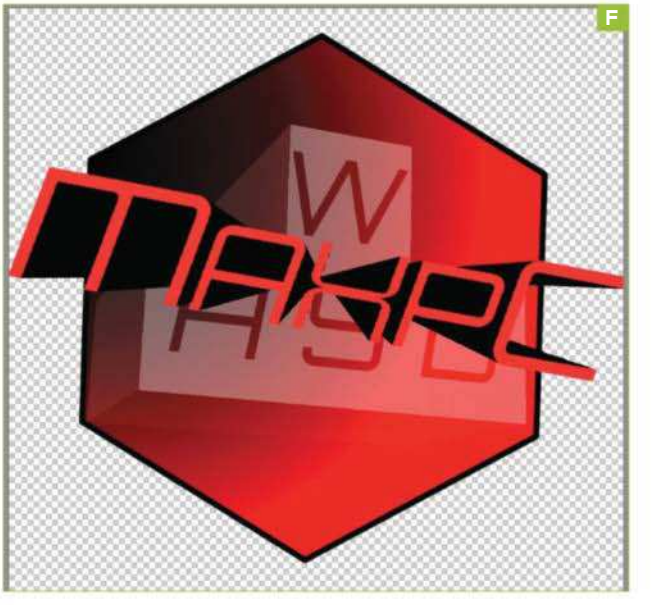
5 FLYING COLORS

Bringing back the original text layer, we move it a little to ensure it doesn't clash with the one behind, using Free Transform, which converts the 3D to a Smart Object, to change the angle of the rotation. Eventually, when we're happy, we rasterize the layer by right-clicking it on the Layers palette, and choosing the "Rasterize" option. We do the same for the WASD layer, and throw a hexagon behind the whole thing using the shape tool [**Image E**]. The shape appears both on its own layer and as a path, so it's easy to load its outline as a selection, and drag a gradient across it with the Gradient tool, which nestles in the same place as the Bucket. Stroke the path, again from the Paths palette, to give it an outline—stroking uses whatever settings you currently have attached to your Brush tool, so set this up along with the color you want first, keeping the tool selected. Experiment with the background color, because this has a huge effect, and can totally change how easily recognizable your logo is. We tried a simple black-to-white blend before using the same red we'd used for the initial text [**Image F**].



6 READY TO PLAY

We change the blend mode of the WASD layer to Screen, and fade it out a bit to give the text layer extra punch, and use the Levels adjustment ("Image → Adjustments → Levels") on the Hexagon layer to lighten its colors slightly, because they're too dark for our liking. Then, with the layer structure saved as a PSD file, we can hide or remove the Background layer, then export the logo as a transparent PNG file ready for use. And now team MaxPC can go play *Overwatch*.



BUILD IT

ZAK STOREY, DEPUTY EDITOR

Phanteks-Powered RGB

Churning away inside this month's machine is Intel's Core i3-8350K—is it worth the dollar?

LENGTH OF TIME: **2–3 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

THERE ARE MANY reasons why we're not particularly fond of RGB here at *Maximum PC*. We are, perhaps, more than a little bored of it at this point in time—and who wouldn't be? As more and more manufacturers try to cram those tiny LEDs into every different type of computer component, it's easy to see good design go out the window for the sake of more sales.

But perhaps the problem lies less with RGB itself and more with how it's marketed. After all, when the first monitors utilizing those tiny light-emitting diodes came into existence, we didn't have a perpetually scrolling rainbow gradient titillatingly dancing its way across the screen, did we? It's about choice; about displaying what you want. And that's exactly what it should be. Feeling red today? Then switch everything red.

RGB shouldn't be about funky patterns and grotesque combinations of multi-colored atrocities lurking inside your rig, but more about taking the thematic nature of builds that we used to see 10 years ago, and accentuating them with modern design and contemporary lights, in colors that suit the environment—build yourself that black and red Asus motherboard, the green flecks of a Gigabyte system, or, to hell with it, turn the whole thing pink. Surely, that's the point?

Perhaps we're just a bit too strung up on it. Well then, let's see what we can do with RGB, instead of just moaning about it. This time around, we're going to take some mid-range RGB components on a journey to see what exactly we can do with the medium that doesn't seem to be disappearing anytime soon.

INTEL UNLOCKED

IT'S ODD TO THINK that outside of review, we've never had a proper in-system look at Intel's Core i3-8350K. It's a part that's had something of a strange legacy. Indeed, when the first unlocked Core i3 launched in 2017, it was an oddity. Who the hell would want an unlocked dual-core, with Hyper-Threading, that's priced just shy of a base-level quad-core i5? At the time, it seemed ludicrous. Today, on the other hand? Well, with Intel's bumped-up core count, that dual-core i3 is turned into a quad-core one, making it more akin to last gen's i5 than anything else, and weirdly, given the state of gaming today, far more attractive than its predecessor—although, admittedly, you could still nab the Core i5-8400 hex-core part for only $20 more.

Next up on the list of "pretty things we wanted to use for this build" is Phanteks's latest P350X ATX chassis. It's a super-sweet compact budget tower that, if we're honest, is one hell of an easy sell. As usual with Phanteks, it has managed to transplant the top features that are baked into its more premium offerings into the design of its budget models. Yet it's the aesthetic aspects that really caught our attention: the sharp LED lines in the front panel, with expansive airflow intakes, and the addressable LED strip running alongside the bottom of the PSU cover. It's all there.

Now we're on the topic of custom-lit components, what other illuminated parts did we opt for? Well, there's the Cooler Master MasterAir MA610P CPU air tower, the 16GB of HyperX Predator DDR4 RGB memory, the Gigabyte Ultra Gaming 2.0 motherboard, and the Sapphire Radeon RX 580 8GB Nitro+ with its RGB logo. We've also included a 30cm white LED strip hidden along the front, just to help light up the interior for photography.

INGREDIENTS

PART		STREET PRICE
Case	Phanteks Eclipse P350X	$75
Motherboard	Gigabyte Z370 Aorus Ultra Gaming 2.0	$170
CPU	Intel Core i3-8350K	$169
CPU Cooler	Cooler Master MasterAir MA610P	£40
GPU	Sapphire Radeon RX 580 8GB Nitro+	$350
Memory	16GB (2x 8GB) HyperX Predator RGB 2,933MT/s	$321
PSU	750W Corsair RMx White 80+ Gold	$155
Storage 1	250GB Samsung 750 Evo 2.5-inch SSD	$209
Storage 2	525GB Crucial MX300 SSD	$140
OS	Windows 10 Home 64-bit	$100
Total		$1,729

1 CABLE TRAINING PSU

SINCE HAVING our modding buddy and Alphacool's marketing honcho Dave Alcock to help last issue, we've learned a lot about the subtle art of perfecting PCs. It's always good to collaborate on a build with a friend, especially one who potentially has more experience than you. Apart from shouting at us for not sleeving our own cables, he did teach us the art of cable training. In short, if you haven't sleeved your own cables to the exact length you need, or have cable combs attached, you can train your cables to lie a certain way. To do this, work out where your cables are going ahead of time, group them together, and bend them the way you need, to plug in to the various sockets, taking the grommet into account. Keep a tight grip, and essentially wring them back and forth, until they fall the way you want. It's not perfect, but it's better than leaving them as they come.

2 THREADING THE NEEDLE

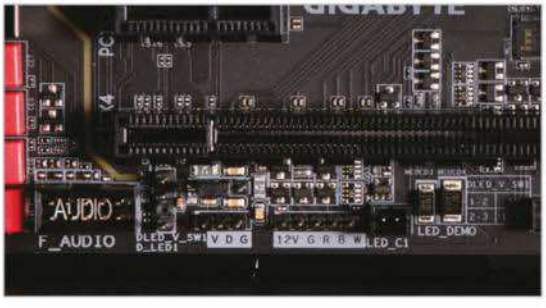
ANOTHER PRO TIP we picked up was with regard to fan connectors—namely, where to thread them through. The front fans in this build were particularly troublesome to route; for the top fan, we ended up routing the cable through the hole in the chassis you can see below. Obviously, there's a big issue with that: the fact that the rectangular PWM fan head won't fit through. In short, you have to detach the plastic fan header. To do this, use a small flat-headed screwdriver, and push down on the clips holding the cables in place on the header. Then, carefully pull the cable out—remember which cable plugged into what hole in the header. Thread the cable through the hole, then push the cables back into the plastic header until they click into place, and you're good to go.

3 CPU TOWER & COOLING

THERE'S NO DENYING that the Cooler Master MasterAir looks bad-ass. At first glance, it seemed as though the two fans were symmetrical on either side, making us believe that both of them were pushing air inward, and the tower was exhausting that heat upward. Because of that, we installed two exhaust fans in the roof, drawing air out of the chassis, and even considered running another fan in the rear as an intake. On closer inspection, however, although they look symmetrical, the blades on the fan to the rear of the tower are actually inverted, meaning the orientation we have currently draws air in through the front, and pushes it out of the back. Our air-cooled setup still work fines here, but now we'd love to install an additional 120mm in the rear as an exhaust as well.

4 RGB CONNECTORS

SO, IN THIS WORLD of RGB interconnected goodness, where exactly do you plug in all of this well-lit paraphernalia? Well, there are two types of RGB header available: There's the 12V RGBW header, which is the standard analog connector, for simple functioning LED strips; and there is also the VDG header, or the addressable header, for when you're plugging in addressable LEDs (which means you can tell each LED in a strip how to operate). Gigabyte's Z370 Ultra Gaming 2.0 has two VDG headers, and two 12V RGBW headers. The 12V RGBW header has five pins on it, and most likely your RGB LED strip will have four pins; to install it, simply plug it into the 12V RGB section, leaving the W pin unconnected. For anything addressable, the VDG header is your gal. Either way, you'll want to make sure you line up the arrow on each connector with the 12V part of the connector, and you'll be ready to go.



5 GPU BLOCK

WE DECIDED to shake things up for this build, and whip out one of our current favorite AMD cards, the RX 580 Nitro+. Thanks to those ASIIC miners coming into production, the price of GPUs has plummeted, both for AMD and Nvidia. One thing we would say is that if you're looking to make every penny count, we'd drop the Nitro+ Special Edition, and opt for a cheaper RX 580 instead, because you'd probably net yourself a pretty $30 saving, too. Either that or go for a fairly well-priced GTX 1060 6GB instead. The reason we love the Nitro+ so much, at least for this build, is the sexy backplate on what is technically a mid-range card. It's crisp and clean, and with the white, black, and silver color scheme matching the rest of our build's accents, it really brings the whole system together nicely.

6 FU-SION HA!

LET US KNOW if you get that reference. Anyway, back to setup. So, you've got your RGB memory installed, your CPU heatsink plugged into your mobo, and your RGB LED strip in there, too. How on earth do you align this plethora of LEDs? Well, most motherboards come with some form of RGB LED controller software. In Gigabyte's case, that's the Fusion App, found in its App Center, and downloaded from its website. Simply load it up, and you can control every RGB LED connected to your mobo, DIMMs, and all. If you want to control individual segments of the motherboard, head into the advanced header for even more options.

1 **If only we sleeved our own cables—expect a tutorial covering that exact topic soon!**

2 **Sapphire's Radeon RX 580 graphics card has almost returned to a reasonable price.**

3 **The Phanteks P350X chassis has a multitude of RGB modes for the LED lights.**

4 **Cooler Master's MasterAir touches the side panel, but you can still secure the window.**

PURPLE POWER

AFTER OUR liquid-cooling colossus last month, this was a walk in the park. Built in an afternoon, the most difficult part of its construction was figuring out how to install the CPU heatsink (hint: outside the case), and dealing with the fact that it's ever so slightly bigger than what the case can support (it's touching the glass, but everything can be secured down just fine). Aside from that, it was plain sailing. It gave us the chance to put into practice some of the skills we'd learned from our modding friend regarding cable management. A dream build. Two hours, at the end of a fairly friendly working day—what more could we ask for?

With all that spare time, we got to grips with tweaking and tinkering with the system; in particular, overclocking the Core i3. From the get-go, we decided we'd use Intel's XTU desktop software to do some basic overclocking, but after some less than stellar results, ended up diving into the BIOS anyway. With a small bump up in the voltage to 1.4V, we managed a nice 4.6GHz. Not massive, but it did net us scores of 751 in Cinebench R15's multicore, and an incredible 198 in single-core. We did get it running at 4.7GHz on 1.42V, but couldn't achieve any higher than that; 4.8GHz would've been nice, but it just wasn't meant to be. 4.6GHz gave us some solid performance, and "acceptable" temperatures. It's worth noting that our office is at a constant 21 C ambient temp, so it is a little easier for us to achieve a steady overclock, even in summer. That said, at 4.6GHz, our MasterAir was hitting around 72 C under load with 1.4V, so your mileage may vary. If you do plan on clocking a Core i3-8350K higher, you may very well need a more substantial cooling solution, as Coffee Lake is an exceedingly hot part.

When it comes to graphics, it was quite refreshing to go back to AMD, even temporarily, with the RX 580 8GB. It performed well in our tests—not quite up to scratch compared to our GTX 1060 zero-point, but it did well nonetheless. If you have a FreeSync 1080p monitor setup, having a GPU that's capable of driving those kind of numbers at ultra is a fairly sound deal. Again, though, we advise trying to find a cheaper RX 580 than ours.

All in all, it went well. There were no major issues, no first-time boot conundrums, and no stress. Combine that with the sleek aesthetic, stunning case, and fine lighting provided by the combination of Gigabyte's Fusion software and Sapphire's TRIXX RGB software, and it's a build that we're damn proud of.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	751 (-35%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	556 (-84%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	525 (-69%)
Rise of the Tomb Raider (Avg fps)	60	57 (-5%)
Total War: Warhammer II (Avg fps)	46	45 (-2%)
Tom Clancy's Ghost Recon Wildlands (Avg fps)	39	40 (3%)
3DMark: Fire Strike (Index)	11,101	11,850 (7%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2666, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1080p at the highest graphical profile.

techradar.

The home of technology

techradar.com

REVIEWS

TESTED. REVIEWED. VERDICTIZED.

INSIDE

74 AMD Ryzen 5 2600
76 Gigabyte X470 Aorus Gaming 7 Wi-Fi
78 Acer Swift 3 SF315-41
80 Samsung C49J89
82 Samsung 970 Pro 512GB
83 Kingston KC1000 HHHL 960GB
85 Logitech G513 Carbon (Linear)
87 Corsair Crystal 280X RGB
89 Corsair HS70 SE Wireless
90 BattleTech
91 Thrones of Britannia: A Total War Saga
92 Lab Notes

AMD RYZEN 5 2600 PAGE 74

AMD Ryzen 5 2600

The perfect hex core for the tinkerer

AMD'S RECENT SUCCESS in the processor market has been staggering. With Intel expecting big losses in the server segment, and AMD pulling back market share elsewhere, too, Big Blue definitely seems to have been caught off guard. But if we're honest, as much as it's good to see Team Red get back on its feet after a rather disastrous few years, especially in the enterprise domain (which is where the vast majority of the money lies), it's the mid-range computing segment that interests us the most, and in particular, finding that sweet-spot chip that represents the perfect balance between price and performance. Typically speaking, as you go further down the product list, you eventually reach a point where that bang for buck figure starts to decline, and you begin to see an overall decrease in value per dollar. For Nvidia, that's anything below a GTX 1050; for Intel, the Celeron series; and for AMD, well, it was the Ryzen 3 series—at least, before this generation anyway.

The Ryzen 5 2600 is currently at the bottom of AMD's list of recently refreshed 12nm processors (excluding the integrated GPU series), so is that old maxim true? Do we start to see a degradation in performance over price? The short answer: no, we don't. Amazingly, out of the whole lineup, the 2600 is, by far, the most cost-effective AMD part you can get right now. In our price to performance metric (Cinebench R15 multi score split by the price at time of writing), the 2600 scores higher than every other AMD chip we've seen so far from this refresh (6.71 versus the 2600X's 6.57, and the 2700X's 5.5). That makes it a pretty attractive offering for anyone looking to piece together a mid-range build. Couple this part with a 3GB GTX 1060, 8 or 16GB of DDR4, and a 120GB SSD, and you're immediately looking at a very attractive cost-effective 1080p gaming and amateur video editor/streaming machine.

The bang for buck element is definitely there. At stock, all six of those 12nm cores are pretty impressive, scoring 159 points in the Cinebench single-core test, and 1,274 points in multicore mode, with the rest of our computational benchmarks following suite. That single-core result is perhaps a little lower than most are looking for in game, but nothing so detrimental that you'll notice. Power draw was a solid result, too. Coming in at 52W at idle and 148W under load, it rounds out this chip nicely.

That said, everything else is kind of where you'd expect, the only notable exception being the *Total War: Warhammer II* benchmark smashing all our test subjects, scoring an average frame rate of 79fps at 1080p, toppling even the 2700X.

But, of course, for the non-X parts, the trick is how far you can push them when it comes to clock speeds. And the 2600 is no different—with a quick clock ratio adjustment up to 43, 1.45V dumped into the V Core, and some tweaking of the VRM settings, we managed to get a very stable 4.3GHz (or 4,290MHz) out of all six cores, no sweat. This bumped up the temps a bit, with load temp reaching 72 C with a 360mm rad, but it was more than happy smashing through all our benchmark tests again.

The Ryzen 5 2600 really epitomizes what Ryzen is all about: balance. The right number of cores, the right stock performance, the right overclocking capability, the right thermals, at the right price, and it even comes with a pretty jazzy CPU cooler, too. If we had one reservation, it's that it still suffers from slightly higher latency issues than its competitor, but honestly, for the target audience, that matters very little. - **ZAK STOREY**

BENCHMARKS

	AMD Ryzen 5 2600	AMD Ryzen 5 1600X
Cinebench R15 Single/Multi (Index)	**159/1,274**	**159**/1,223
Tech ARP's X264 (Avg fps)	**27.7**	27.1
Fry Render (m:s)	**03:09**	03:15
AIDA64 Latency (ns)	72.2	**71.1**
AIDA64 Memory Bandwidth (MB/s)	**47,171**	45,636
Power Draw Idle/Load (W)	52/148	**45/115**
Total War: Warhammer II @ 1080p (Avg fps)	**79**	76
3DMark Fire Strike Dedicated (Index)	17,204	**17,235**
Maximum Overclock (GHz)	**4.3**	3.9
Price to Performance (Index)	**6.71**	6.12

Best scores are in bold. Our test bed consists of an MSI X470 Gaming M7 AC, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1080p on the highest graphical profile.

VERDICT **9** KICK ASS!

AMD Ryzen 5 2600

+ RYZEN UP Balanced part; strong overclocking; good thermals and power draw; strong price point; good integrated cooler.

– RYZEN FUEL PRICES Memory latency still an issue.

$190, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.4/3.9GHz
Cores/Threads	6/12
Lithography	12nm
Cache (L3)	16MB
Memory Support	64GB @ 2,933MT/s
Memory Channels	2
Max PCIe Lanes	16+4
TDP	65W

Another value king from Team Red.

Fin-tastic. We'll let ourselves out....

Gigabyte X470 Aorus Gaming 7 Wi-Fi

All the Gigabyte goodies

YOU KNOW WHAT'S AWESOME about this motherboard? The heatsinks. Seriously, look at them: real heatsinks. OK, portions of them are covered in stylistic design elements, sure, but those are genuine fins there, capable of dissipating really hearty VRM thermal energy far better than any of the standardized aesthetic affairs we've been seeing for the last few years. Even though each generation of die shrink typically increases the number of transistors by 40 percent or more, the actual real-world performance increase has been more than lackluster in comparison. What this has lead to is the big chip manufacturers scrambling to get as much performance as possible by other means. Whether that's through architectural changes, or more advanced technical measures (such as increasing core count through multiple dies), this has lead to a significant increase in overall power being pumped through the VRMs. More power means more heat, and eventually, especially when overclocking, this leads to VRMs throttling the amount of voltage they manage, to ensure they don't breach their own thermal limits, which in turns slows down the processor.

We've seen it with X299, we've seen it with Coffee Lake, and we've even seen it at the higher end of Ryzen—if you want the absolute maximum performance you can possibly get from your chip, having heatsinks that are, you know, actually effective is of paramount importance.

But let's get serious—this is the Aorus Gaming 7 Wi-Fi, Gigabyte's finest X470 flagship. Aside from the glorious fins lining the VRMs, it comes packing absolutely everything the Taiwanese company could pitch at a board. We're talking twin M.2 heatsinks, copious amounts of RGB connectivity and lighting, a premium DAC solution, dual eight-pin and four-pin EPS power, a 10+2 CPU power phase setup, eight PWM fan headers, a reinforced backplate, a whole host of internal USB headers, wireless A/C, and enough rear I/O to keep even the most avid USB enthusiast happy. If you can think of it, and it's possible to fit it on the board, it's here.

PERFORMING ARTS

All that frilly stuff aside, the Gaming 7 performs admirably where it matters. In our tests, it scored a solid 33.6fps in our x264 benchmark, and a stable 1,652 points in our Cinebench R15 multicore test. Power draw was on a par with our other top-end board, as were games. The only thing that was slightly down was the CrystalDisk QD32 sequential write speeds at 428MB/s versus the Crosshair VI's (our comparative board of choice) 450MB/s. But all in all, a solid performance.

Overclocking was not hugely different; we managed to hit our Ryzen 7 1800X's limit of 4GHz across all eight cores easily enough at 1.425V on the VCore. That's a little higher than we would have liked, with the Crosshair VI Hero managing it at 1.4V. That said, with the Crosshair, you do have access to power tweaker options, including VRM settings, which do make a big difference in such a situation. For high overclocks and extensive long-term load, that additional 10+2 power phase, combined with the VRM finned heatsinks and advanced EPS power setup, should make a substantial difference in keeping everything running smoothly.

The X470 Gaming 7 Wi-Fi is a premium board, at a reasonable price, with a massive feature set. For anyone looking to get into streaming, rendering, or more, it's the brilliant combination of form and function. It's not perfect, for sure—Gigabyte still needs to do a lot of work with its BIOS and overall software design—but it definitely falls into that "greater than the sum of its parts" mantra, and that's something we can absolutely get behind. **–ZAK STOREY**

VERDICT 9

Gigabyte X470 Aorus Gaming 7 Wi-Fi

+ HIGH FLYER Consistent performance; value for money; extensive feature set; good for video editing; very stable.

– QUAGMIRE Software and BIOS still need work.

$230, www.gigabyte.com

BENCHMARKS

	Gigabyte X470 Gaming 7	Asus Crosshair VI Hero
Tech ARP's X264 (Avg fps)	**33.6**	33.06
Cinebench R15 Multi (Index)	1,652	**1,664**
Fry Render (m:s)	**02:45**	**02:45**
AIDA64 Latency (ns)	**95.8**	96.8
CrystalDisk QD32 Seq Read/Write SATA (MB/s)	**551**/428	540/**450**
Power Draw Idle/Load (Watts)	50/**277**	**47**/278
Total War: Warhammer II (Avg fps)	**57**	**57**
Lowest Voltage @ 4GHz (Volts)	1.425	**1.4**
Maximum OC Achieved (GHz)	**4.0GHz**	**4.0GHz**

Best scores are in bold. Our test bed consists of an AMD Ryzen 7 1800X, 16GB of Corsair Dominator Platinum DDR4 @ 3,200MT/s, an Nvidia GeForce GTX 1080, and a 250GB Samsung 850 Evo. *Total War: Warhammer II* was performed on the Ultra preset at 1440p.

SPECIFICATIONS

Chipset/Socket	X470/AM4
Form Factor	ATX
Memory Support	64GB DDR4 @ 3,600
M.2/U.2 Support	2x M.2
SATA Support	6x SATA 6Gb/s
Max PCIe Support	3x PCIe x16 (max PCIe x8x8)
Rear I/O	1x USB 3.1 Type A, 1x USB 3.1 Type C, 6x USB 3.0, 2x USB 2.0, Intel Gigabit Ethernet, Wireless A/C, 5.1 audio, optical audio out, clear CMOS, power button.

Acer Swift 3 SF315-41

AMD's Ryzen makes the move to mobile

SINCE FOREVER is a long time to wait, but that's effectively how far back you have to go to find a decent mobile CPU from AMD. In other words, it's debatable whether AMD has ever made a truly competitive laptop chip. Yes, AMD's mobile processors based on the Bobcat core were OK for budget devices, but Intel's domination has been even stronger in laptops than it already was on the desktop.

Or at least until Ryzen came along and proved how complacent Intel has become. But that's just desktop, right? This is mobile and, at last, Ryzen has made that transition to laptops, and we can finally tell you whether it's as big a game changer in the portable market as it has already proven to be on the desktop. Well, that was the plan, courtesy of the Acer Swift 3. On paper, it's the ideal system for weighing up the relative pros and cons of the latest mobile CPUs from AMD and Intel.

That's because it's one of the very few mobile rigs offered with both AMD Ryzen and Intel Core processors. Yes, variables remain, including the motherboard, but the really critical bits, such as the screen, chassis, and battery, are shared by both variants, providing about as level a playing field as you're ever going to get.

In practice, it doesn't quite work out like that. But first, let's dissect exactly what Acer is offering with this AMD-powered Swift 3. For the most part, it's a resolutely middle-market offering in a 15.6-inch form factor. It's powered here by the Ryzen 5 2500U. That's the second tier in a four-strong range of mobile Ryzen CPUs. The 2500U has the full complement of four cores and eight threads on the CPU side, but it loses a pair of compute units from its AMD Vega graphics core. Where the Ryzen 7 2700U gets 10 compute units, the 2500U makes do with five.

The 2500U is also 200MHz down on clock speed, with a base clock of 2GHz, and a maximum Boost clock of 3.6GHz. But overall, it's a good introduction to Ryzen's mobile capabilities. Elsewhere, the Swift 3 boasts a Full HD IPS display covered in Corning Gorilla Glass, and a 256GB M.2 SSD hooked up via SATA, rather than the powerful PCI Express interface. In terms of physical attributes, it's an intriguingly mid-sized aluminum affair, rather than a truly thin-and-light option, packing a curb weight of 4.85lb, and equipped with a 48Wh battery.

That battery not only reveals the Swift 3's mid-market positioning, it also makes it tricky to get a feel for how efficient AMD's Ryzen processor is in a mobile implementation. A premium 15-inch portable, such as Dell's XPS, offers roughly double the battery capacity, for instance. Making matters worse, we had problems getting our pre-production review sample up to full charge. In short, we couldn't assess the unit's battery life at all.

If we're honest, that pretty much sums up our experience with the Swift 3 as a whole. During testing, this laptop kicked out a fairly mixed bag of results, both in outright terms, and in the sense that performance in the same test varied widely over the course of multiple runs. We extracted scores varying from 340 to well over 500 for Cinebench in multithreaded mode, even with Windows Update turned off. The graphics performance of the AMD Vega 3D core was also patchy.

Very likely, all of that reflected our review unit's pre-production status. Maybe the firmware needs a tweak, or the cooling hasn't had that final polish. Whatever, the overall sense is that this isn't Ryzen mobile at its best. That's a pity, not only for this laptop—it's a solid little unit, with a nice IPS panel, and a firm feel to its keyboard performance—but also for the Ryzen chip, which looks very promising indeed. For now, our feeling is that Ryzen will give certain members of Intel's latest eighth-gen mobile CPU range a very serious run for their money, but we'll need to spend time with a better optimized system for a more detailed conclusion. **–JEREMY LAIRD**

VERDICT 7

Acer Swift 3 SF315-41

SPEEDY GONZALEZ Good overall package for price; high-quality display; quad-core performance.

PEPÉ LE PEW Pre-production system not firing on all cylinders; relatively small battery.

$699, www.acer.com

BENCHMARKS

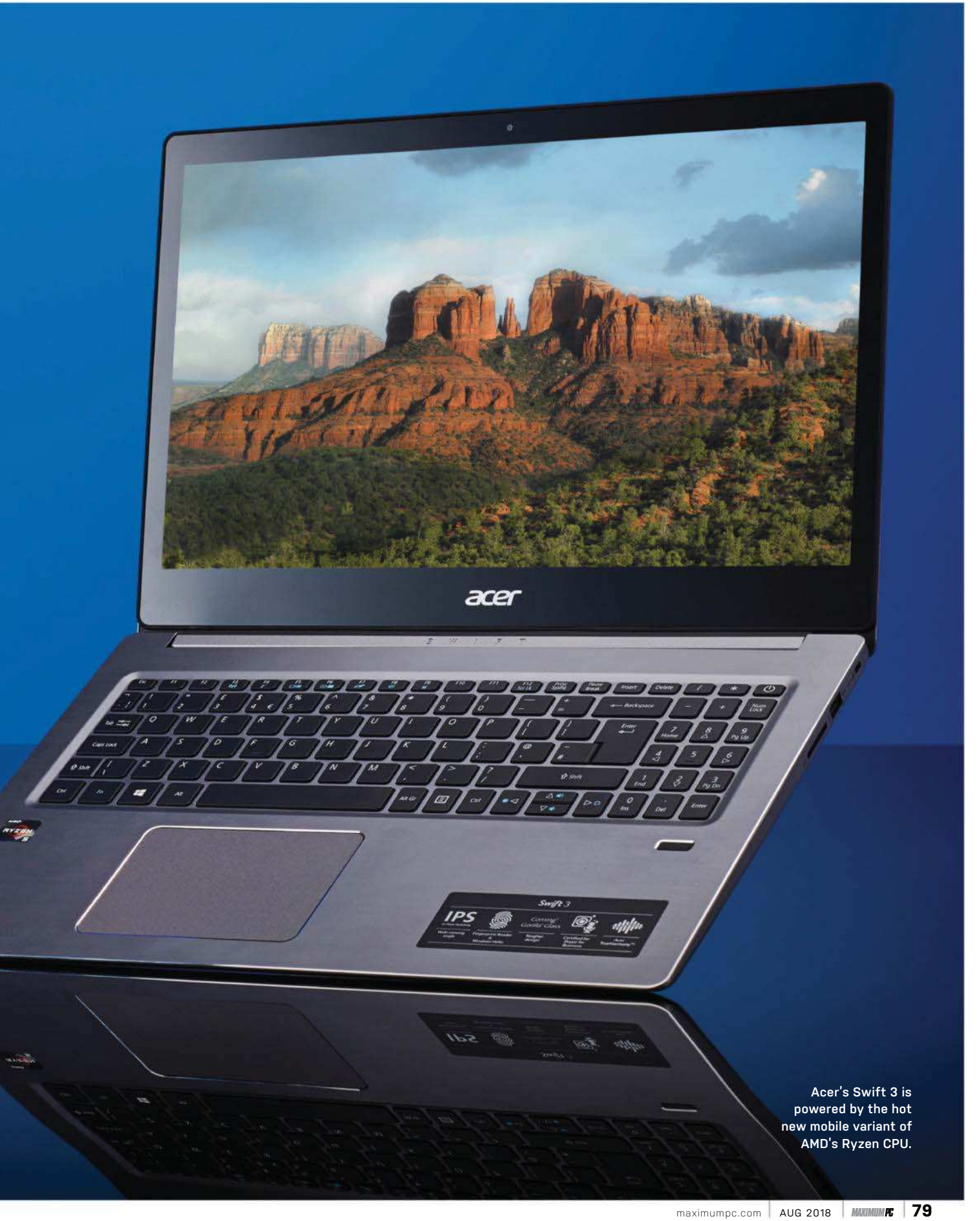
	ZERO-POINT	
Cinebench R15 Multi (Index)	743	550 (-26%)
CrystalDiskMark QD32 Sequential Read (MB/s)	563	508 (-10%)
CrystalDiskMark QD32 Sequential Write (MB/s)	133	260 (95%)
PCMark 10 Express (Index)	3,852	2,777 (-28%)
3DMark: Fire Strike (Index)	13,202	768 (-94%)
Rise of the Tomb Raider (fps)	99	11 (-89%)
Total War: Warhammer 11 (fps)	62	9 (-85%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700 HQ, an 8GB GTX 1070, and 16GB of DDR4-2400. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	AMD Ryzen 5 2500U
Graphics	AMD Vega 8
Memory	8GB DDR4
Resolution	1920x1080
Display Type	IPS
Primary Storage	256GB M.2 SATA
Additional Storage	N/A
Connectivity	HDMI, USB 2.0, 2x USB 3.0, USB C, headphone
Dimensions	0.7 x 14.6 x 10 inches
Weight	4.85lb
Warranty	One year



Acer's Swift 3 is powered by the hot new mobile variant of AMD's Ryzen CPU.

Samsung C49J89

So, you said you wanted widescreen...

STOP THAT. It's silly. This, we wager, is roughly what goes through your mind as you regard Samsung's latest ubertron, the C49J89. It isn't just physically huge in objective terms, measuring 49 inches across its outrageously ample diagonal. It's also visually vast, thanks to its extreme 32:9 aspect ratio. Surely, this isn't sensible?

But hold on. When the first superwide 21:9 aspect monitors appeared, opinion was divided. Now they're relatively mainstream and extremely popular. Could familiarity normalize the C49J89's even wider proportions in a similar manner?

Hold that thought as we run through the key speeds and feeds. Panel-wise, we're talking 49 inches of VA shizzle with an 1800R curvature. It's good for a static contrast ratio of 3,000:1, which is nice, and peak brightness of 300cd/m^2, which is less stellar in this brave new age of HDR. Indeed, this reveals the key difference between the C49J89 and its otherwise similar Samsung sibling, the CHG90. The C49J89 lacks support for HDR visuals.

That said, it does pack a pretty nifty set of broader capabilities. For starters, it runs up to 144Hz refresh, which isn't necessarily what you'd expect for a monitor mainly aimed at productivity. Next up is a built-in KVM switch, giving you lots of options for hooking up multiple machines to drive the display. USB C connectivity is another bonus, allowing a single cable to both drive the display and charge a laptop.

The C49J89 also supports Samsung's DeX Station interface, enabling you to dock your Samsung cell phone with the monitor, mirror its interface, and use a keyboard and mouse to control the whole shebang. But the key specification, the one that really defines this screen, is the native resolution of 3840x1080. The horizontal figure is the same as a standard 4K or UHD display, but the vertical is just half the 4K standard. In simple terms, you have a pair of 1920x1080 FullHD monitors sitting side by side.

The upside is that you're getting that with absolutely no divide, no bezels between two displays; just one glorious, gently curved expanse. The first downside is that this is not a cheap display, and those 1,080 vertical pixels are a major limitation compared to, say, a pair of cheap 1440p panels, much less dual 4K monitors, both of which are very much doable for similar or less cash than the C49J89. The next is that while 3,840 pixels sounds like a lot, spread across a 49-inch diagonal, they make for a pretty large pixel pitch. A Retina-style display this most definitely ain't.

In other regards, the panel quality is decent. Granted, the viewing angles are limited compared to the best IPS monitors. And it lacks pizzazz next to the latest quantum-dot and HDR-enabled screens. But that 3,000:1 contrast ratio makes for nice, deep blacks, and the colors are pleasing, if not punchy.

However good the panel quality, the form factor and resolution are what this screen is about. For gaming and movies, it's suboptimal. There's almost no video content this wide, and most games don't offer a field of view that makes the most of the aspect ratio. For productivity, the C49J89 makes a better case for itself as an alternative to a dual-monitor setup. But even there the lack of pixel density and vertical resolution are problematical. The earliest 21:9 monitors suffered from a similar lack of pixels, but even with more pixels, the appeal of ultrawide 32:9 monitors is likely to stay narrow. **–JEREMY LAIRD**

VERDICT **7**

Samsung C49J89

EXPANSE Decent panel quality; very large, very impressive.

EXPENSE Not enough pixels; pricey for the quantity of desktop space.

$1,099, www.samsung.com

SPECIFICATIONS

Panel Size	49 inches
Native Resolution	3840x1080
Pixel Density	81 ppi
Panel Type	VA
Maximum Refresh	144Hz
Response	5ms
Contrast	3,000:1
Display Inputs	DisplayPort, HDMI, 2x USB C
Connectivity	USB, audio
VESA Mount	100 x 100mm
Warranty	One year

Samsung's latest monitor takes "widescreen" to a whole new level.

Samsung 970 Pro 512GB

Samsung just got scarier

SSD MAKERS across the globe: Prepare for a world of pain. The 970 Pro is part of Samsung's third generation of high-end NVMe SSDs. Its previous efforts have been about as good as consumer SSDs got. So, if third time truly is lucky, and the 970 Pro is even better, well, Samsung just got scary.

Of course, it's over 18 months since the Samsung 960 Pro debuted. That's an aeon in the ironically fast-moving world of solid-state storage. In that period, Intel has rebooted expectations when it comes to solid-state memory latency, with its revolutionary 3D Xpoint tech, sold in products under the Optane brand. Meanwhile, several other SSD manufacturers have upped their game, too.

So, what does the 970 Pro, reviewed here in 512GB capacity, bring to the M.2-format SSD game? Inevitably, there's a new controller chipset, the Samsung Phoenix. We saw it before in the 970 Evo, the 970 Pro's cheaper sibling. Equally inevitably, not much is known about Phoenix. Just like Samsung's previous NVMe controllers, Phoenix uses a PCIe 3.0 quad-lane interface with eight channels. It also has five CPU cores, like the outgoing Polaris.

But that's about it. Samsung never goes into real detail when it comes to the specifications of its SSD controllers. That said, Phoenix is also used in Samsung's megamoney enterprise SSDs, so it's clearly the company's best controller tech. We also know that the 970 Pro uses Samsung's new 64-layer 3D MLC V-NAND. Such is the data density of this new generation of NAND flash memory, its 512GB TLC dies allow for 1TB in a single BGA package. That makes larger capacities easier and cheaper, even if this Pro model remains a premium-priced proposition.

Still, for the extra money, Samsung provides significantly more drive endurance. The new 970 Pro is far ahead of both its predecessor and its 970 Evo sibling in that regard. The old 960 Pro 500GB drive was rated for 400TB of writes, and the 970 Evo is good for 300TB—the 970 Pro 512GB is rated at fully 600TB.

All told, then, the on-paper progression from 960 Pro to 970 Pro is significant, but not always dramatic. Maximum sequential reads remain pegged at 3.5GB/s, probably reflecting the real-world limits of the quad-lane PCIe interface. Sequential writes for this 512GB model have stepped up from 2.1GB/s to 2.3GB/s. As for 4K performance, that's up from 330K IOPS for reads to 370K IOPS. Writes increase from 330K to 500K.

But what about in benchmarks? Our results indicate the peak throughput claims are pretty much on the money. Unlike cheaper drives, such as the Kingston KC1000, reviewed opposite, the 970 Pro maintains performance close to the claimed peak throughput, regardless of the benchmark. Even more impressive, arguably, is the 970 Pro's real-world performance. It absolutely tears through our internal file copy test, completing it in just 29 seconds. That's twice as fast as the new Kingston KC1000, again by way of example.

Indeed, during our pre-test setup, which involves completely filling a drive before wiping it clean again, the 970 Pro sustained internal file copy speeds of around 1GB/s. Very few SSDs can achieve anything close to that kind of sustained performance over hundreds and hundreds of gigabytes.

Overall, then, it's likely that the 970 Pro remains among the best if not the very best consumer SSD. The step forward this time around is arguably a little more modest in some ways than before, but that only reflects the limitations of NAND memory technology hooked up via a PCIe 3.0 interface. A bigger leap forward probably requires a step-change tech, like Intel's 3D Xpoint. Sufficiently refined, 3D Xpoint could provide just that. But for now, the 970 Pro is about as good as consumer SSDs get, albeit at a price. –JEREMY LAIRD

VERDICT **9**

Samsung 970 Pro 512GB

SCARY MOVIE Excellent all-around performance in our benchmarks; just as good in real-world metrics.

SCARY PRICE Very expensive for the capacity; you won't feel the performance advantages most of the time.

$249, www.samsung.com

BENCHMARKS

	Samsung 970 Pro 512GB	Intel SSD DC P4510 1TB
30GB Internal Copy (Seconds)	**29**	32
Atto Sequential Read (MB/s)	**3,561**	3,158
Atto Sequential Write (MB/s)	**2,385**	2,059
CrystalDiskMark Sequential Read (MB/s)	**3,112**	1,431
CrystalDiskMark Sequential Write (MB/s)	**2,338**	2,032
CrystalDiskMark 4K Read (MB/s)	**66**	35
CrystalDiskMark 4K Write (MB/s)	**231**	207

Best scores are in bold. Our test bench consists of an Intel Core i7-8700K, an Asus Maximus X Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

SPECIFICATIONS

Capacity	512GB
Interface	PCIe 3.0 x4
Control Protocol	NVMe
Controller	Samsung Phoenix
NAND Type	64-layer 3D MLC V-NAND
Sequential Read/Write	3.5/2.3GB/s
Read/Write IOPS	370/500K
Warranty	Five years/600TBW

Kingston KC1000 HHHL 960GB

Kingston plays the long game with its first NVMe drive

WIND YOUR MIND back to July 2013. That's how long ago the first SSD with support for the hot new NVMe control protocol was launched. Four years later, Kingston finally turned up to the party. Admittedly, that was last summer, so we're equally late to the KC1000's own festivities. The point is, did the KC1000 swagger in fashionably late? Or has Kingston missed out on all the fun?

The answer depends on what you're looking for in an SSD. One of the KC1000's major selling points involves endurance rather than speed. That may be surprising, given performance is the most obvious benefit of moving from an old-school SATA drive, based on the ancient AHCI control protocol, to an M.2 drive connected via PCIe, and leveraging the solid-state optimized NVMe protocol. But the KC1000 not only offers a full five-year warranty, it also backs that up with a two million hours mean time between failures (MTBF) rating.

What's more, Kingston rates this 960GB KC1000 as good for 1PB (1,000TB) of writes. That's far nearer to the 1.2PB of Samsung's market-leading 970 Pro 1TB than it is the cheaper 970 Evo 1TB and its 600TB rating. For the record, our sample comes as part of the KC1000 HHHL package, the latter jumble of letters signifying Half Height Half Length, referring to the bundled add-in PCIe board that allows you to use the drive in motherboards that lack an M.2 slot as standard. A bare KC1000 M.2 drive is available for a little less cash.

As for the spec of the drive, underpinning it all is a Phison PS5007-E7 controller, and a load of Toshiba 15nm planar, rather than 3D, MLC NAND flash memory. At launch in 2016, the Phison PS5007-E7 was intended to be among the fastest NVMe controllers. Today, it isn't quite as competitive.

This 960GB model is pegged at 2.7GB/s for peak sequential reads and 1.6GB/s for writes. 4K random access performance is, again, a fair distance off the very best. At 190K and 165K for reads and writes respectively, it's not going to worry the 500K IOPS capability of the likes of Samsung's 1TB 970 Pro, for instance.

In practice, a similar performance delta applies. The peak throughput numbers in benchmarks are patchy. It exceeds expectations in the least challenging metric, ATTO Disk Benchmark. However, with peak sequential reads of just over 1.5GB/s in CrystalDisk, it's some way short of Kingston's claims. Similarly, 4K random access performance of 42MB/s for reads and 125MB/s for writes isn't merely well behind the likes of a top-end drive like the Samsung 970 Pro, it's also significantly slower than the cheaper 1TB 970 Evo.

That said, it's arguably in real-world apps that the KC1000's outright performance deficit is most obvious. Both Samsung drives are roughly twice as fast in our internal file copy test. Similarly, during our pre-bench setup routine, we found the KC1000's sequential throughput can drop as low as 200MB/s when copying hundreds of GBs in a sustained fashion.

Which means the KC1000 isn't exactly a no-brainer. It will blow away a SATA drive, but compared to the latest PCIe SSDs, it looks pretty ordinary. Countering that is the five-year warranty and the promise of hardcore endurance. If reliability is high on your list of priorities, you might want to join the KC1000 for a drink. –JEREMY LAIRD

VERDICT 8

Kingston KC1000 HHHL 960GB

HOUSE PARTY Excellent five-year warranty; strong endurance ratings.

HANGOVER Patchy performance; questionable value proposition.

$429, www.kingston.com

BENCHMARKS

	Kingston KC1000 960GB	Samsung 970 Evo 1TB
30GB Internal Copy (Seconds)	62	**31**
ATTO Sequential Read (MB/s)	3,045	**3,122**
ATTO Sequential Write (MB/s)	2,314	**2,531**
CrystalDiskMark Sequential Read (MB/s)	1,561	**2,911**
CrystalDiskMark Sequential Write (MB/s)	1,507	**2,495**
CrystalDiskMark 4K Read (MB/s)	42	**68**
CrystalDiskMark 4K Write (MB/s)	125	**171**

Best scores are in bold. Our test bench consists of an Intel Core i7-8700K, an Asus Maximus X Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

SPECIFICATIONS

Capacity	960GB
Interface	PCIe 3.0 x4
Control Protocol	NVMe
Controller	Phison PS5007-E7
NAND Type	Toshiba 15nm planar TLC
Sequential Read/Write	2.7/1.6GB/s
Read/Write IOPS	190/165K
Warranty	Five years

THE GLOBAL AUTHORITY ON PC GAMES

Over **ten million** gamers
visit us online every month.

Join them.

→ PC GAMER.com

Logitech G513 Carbon (Linear)

In which we talk for a while about graphs

THERE'S A SWEET SPOT on the hardware scattergraph that sits between flash and function, statement and understatement, reserved for only the most balanced gear. Most peripherals land nowhere near it, and that's not a bad thing. Everyone's tastes are different. Some like a brash keyboard that drives them on to greatness; others prefer a subtle typer that does its job, then gets out of the way without any fuss. Logitech's G513 Carbon nearly lands on that theoretical midpoint, but—for reasons we'll explain—it's not quite dead on.

Let's start with the switches. Logitech's Romer-G switches are, we think, some of the best in the world right now. We're testing the linear version here (though there's a tactile variety on offer, if that's more your style), and it's a super-smooth experience, with a soft, comfortable action, and some incredibly light actuation. Where Razer's yellow switches (to pull out just one example) can be squishy and indistinct, these are sprung enough in their lower action to provide reasonable feedback, and light enough up top, with a high enough trigger point, that they forgive half-hearted keystrokes readily.

They're not just cleverly designed internally; aesthetically, with the hollowed-out shaft housing a centralized diffused RGB LED (an upgrade from the single color of the G413), the Romer-Gs are some damn pretty switches. That construction directly gives rise to the centrally marked soft-touch keycaps, each of which is anchored on four sides to reduce wobble to a minimum (even on the spacebar). There's basically no light bleed on to the base—essential, we'd say, with a minimalist floating design like this—and Logitech's choice of cap font is bold, clear, and entirely functional.

KEY NOTES

That straightforward industrial design is a common thread that runs through the G513. The only place that harsh edges come into play, beyond the clean lines around the tight edge of the aluminum-topped base, is in the recesses of the replacement keycap selection in the box; drop them in, and you can highlight the gaming keys you want to lock your fingers into. It's a neat way of offering up options to more extreme players, but we didn't struggle for grip without the alternatives. Switch off the RGB lighting, and the keycaps drop back to the most subtle of markings, lending the G513 a totally pro appearance. The minimalism continues with the function keys. F5 onward, in conjunction with the right-of-AltGr Fn key, can each replicate a media or lighting function—there are no more keys than there needs to be. Scroll Lock and Num Lock be damned, because there are just two indicator lights: one for Caps Lock, and one for Logitech's Gaming Mode, which lets you configure keys to disable either in the heat of battle or when you want the Windows key to just go away.

Logitech has even included additional niceties in the form of a somewhat wayward wrist rest, which we found frequently took a wander (your results may vary—we have, we're told, "distressingly awkward" wrist placement while typing), and an extra-fat braided cable, which houses a secondary connector for USB pass-through. It's all really thoughtful, and hard to fault. But here comes that end-of-review "but." But we don't think hackers or hardcore enthusiasts are going to be totally sold on its floating design when there are so many more compact and quirky boards hitting the market. We're not sure there's quite enough pizazz or extra fluff to draw in the most dedicated gamers, particularly as those forgiving switches are prone to catching mispressed keys. And although the feel of the Romer-G linear design hits the mark, straight-up typists, are going to balk at the price. This is a spectacular keyboard, but it doesn't hit that sweet spot—it draws a neat circle around it. It breaks the graph. **–ALEX COX**

VERDICT **8**

Logitech G513 Carbon (Linear)

HISTOGRAM Good linear action; fantastic lighting; clean design.

MISS-TOGRAM No dedicated media keys; not for everyone.

$150, www.logitech.com

SPECIFICATIONS

Switch Type	Romer-G Linear
Form Factor	Full size
Media Keys	Shared
Macro Keys	Software-definable on F-keys
LEDs	Full RGB
N-Key Rollover	26-key
Pass-Through	Yes
Dimensions	5.2 x 17.9 x 1.3 inches
Warranty	Two years

MASTER THE WORLD'S MOST IMPORTANT PROGRAMMING LANGUAGE

Enhance your knowledge with in-depth projects and guides

ON SALE NOW

FUTURE

Ordering is easy. Go online at:

www.myfavouritemagazines.com

Or get it from selected supermarkets, newsagents, or bookstores

Corsair Crystal 280X RGB

Corsair makes a stab at an RGB microATX cube

TAKE A LOOK at Corsair's arsenal of cases, and you'll see there are over 25 different chassis in the mid-tower ATX sector alone. Compare that to the microATX segment, where there's five. Yep, that's it. So, when a new microATX case launches from the Californian giant, you can bet your backside we're on the scene to review it first.

The Crystal 280X is very much a revision of one of that small group. A much-needed update of the first and still impressive Carbide Air 240. Originally, the 240 was a shrunken variant of the Air 540 series, a compartmentalized cube, designed to allow for better temperature control and easier build access.

From the outset, the 280X takes the best of Corsair's Crystal series, and bakes it into a new variant of the fabled micro cube design. With added tempered glass now adorning the front panel, roof, and side, there's no denying how classy it looks. Done badly, tempered glass can seriously restrict airflow, but Corsair has seemingly dodged this issue pretty well. The front panel is a completely solid single piece of glass and plastic; there's around 20mm of clearance between it and the front intake fans (covered by a magnetic dust filter). Turn your attention to the top, and a single pane of glass sits on a set of spacers, elevating it off the recessed dust filter, designed to provide plenty of additional airflow for those exhaust fans you'll be installing in the roof.

Speaking of cooling, as standard the 280X comes with two 120mm RGB fans, one mounted in the front, and one in the roof, connected to an RGB controller unit in the back of the case. As far as storage is concerned, that back compartment supports two 3.5-inch drives, accessible via a small honeycomb door located at the back of the case, near the rear I/O, with a further three 2.5-inch drive bays situated at the front. Aside from a full-size ATX power supply, you can also mount an additional 120mm fan on the rear side panel, too, presumably to draw cool air in to chill those 3.5-inch drives.

Spinning back around to the front compartment, where the majority of your hardware will be installed, and we can see there's room to support up to a 240mm radiator in the front, one on the floor, and one in the roof.

PALTRY PASS-THROUGHS

At first glance, it all looks rather good—however, the Crystal 280X falls down on two major points. In our opinion, this really should have been pitched as an ITX case. Install that small form factor motherboard into the 280X, and you can see there are plenty of rubber grommets in place to allow for your mobo cables to pass through anywhere you like easily enough. Opt for a microATX board, on the other hand, and what you're left with is a single rubber grommet cable pass-through situated on the bottom-right of your mobo.

There's nothing above it, because it's blocked off by the 2.5-inch drive caddy in the other compartment. There's no obvious cable routing solution, either. If you've got a microATX motherboard with a 24-pin port situated anywhere other than right in the middle, there's only one choice: Run it straight up from that bottom-right grommet—and it looks bad.

Then we have the dust filters. The ones located on the rear side panel and on the bottom of the chassis are fine; what you'd expect from a dust filter—securely magnetized in place. The ones behind the tempered glass panels, however, only have large triangular magnetic pads on each corner, and two trapezium-shaped ones in the middle to help hold them down. It's not enough—they feel flimsy, and if placed incorrectly, can bubble up the mesh, ruining the overall aesthetic and premium feel of the whole affair.

It's a shame, because if it weren't for those gripes, there's a lot of neat features to keep us happy here. But that oversight on the 24-pin cable for microATX motherboards—in a case that's predominantly designed to be a microATX chassis—is just too much of a mistake for us to let go. –ZAK STOREY

VERDICT **7**

Corsair Crystal 280X RGB

+ GENUINE BRILLIANCE Looks good; strong cooling support; plenty of room for storage.

– FAKE KNOCK-OFF Oversight on cable routing for microATX; flimsy dust filters; quite pricey.

$160, www.corsair.com

SPECIFICATIONS

Form Factor	MicroATX tower
Motherboard Support	MicroATX, Mini-ITX
Colors Available	Black, white
Window Available	Window only
3.5-inch Support	2
2.5-inch Support	3
Radiator Support	240mm roof, 240mm front, 240mm bottom
Fan Support	2x 140mm front, 2x 140mm roof, 2x 140mm bottom, 1x 120mm rear compartment
Dimensions	13.8 x 10.9 x 15.7 inches
Graphics Card Clearance	300mm
CPU Tower Clearance	150mm
Weight	16lb

CRAFT, BUILD, FIGHT, AND EXPLORE IN THIS BRAND NEW MINECRAFT SPECIAL!

Packed full of build guides, gameplay advice, and tips from your favourite YouTubers, The Ultimate Guide to Minecraft is an essential companion for any Minecraft fan

132 PAGES OF BRAND-NEW MINECRAFT FEATURES
VOL 26
APRIL 2018
GAMES MASTER PRESENTS
100% UNOFFICIAL!
THE ULTIMATE GUIDE TO
MINECRAFT
PS4 • XBOX ONE • SWITCH • PC • PS3 • 360 • PS
NEW TEXTURES TESTED
SHOULD MINECRAFT DITCH ITS CLASSIC LOOK FOR AN UPDATE?
TAKE TO THE SKIES
SOAR, GLIDE AND SCALE NEW HEIGHTS
DESIGN A STEAMPUNK HOT AIR BALLOON
CONSTRUCT A WINDMILL
EVERYTHING YOU NEED TO KNOW ABOUT ELYTRA
FEATURING
BEST UI & HUD MODS
Make Minecraft your own
TO THE END
Surviving the Outer Islands
FLYING MOBS
Take on creatures of the air

ON SALE NOW

FUTURE

Ordering is easy. Go online at:

www.myfavouritemagazines.com

Or get it from selected supermarkets, newsagents, or bookstores

Corsair HS70 SE Wireless

Our new favorite wireless cans?

WHAT'S THE GOLD standard for headphones? How can you review something so subjective and say, unequivocally, that it's good, that it's worth investing in? Us humans are all weird creatures, made from our experiences, nurture, our environment. Our senses are equally as unique. They can be fresh, they can be worn out, they can be flat, or tightly tuned, or they can simply prefer something different. So how on earth can any reviewer—be it us or any other publication, for that matter—go out and say, without a doubt, that these are some of the best headphones we've ever listened to? Well, we've got a simple test: Crank up the volume, listen to your favorite track, and see whether those cans make your hair stand on end. If that tingling sensation shoots across your shoulders and along your arms, if that track evokes an emotional response, we know we're on to a winner.

That should give you a good idea as to where we're heading with this review. Let's start with a little preface, though: We're quite the connoisseurs of wireless headphones here at the mag. After all, when you spend your days using multiple machines at any given time, being wire-free makes your working life far more comfortable. Sure, they have their drawbacks—finite battery life is certainly the biggy, and sound quality over the wireless medium almost always suffers—but in contrast to the alternative, the improvement to your quality of life is just too tempting to pass up, even against some of the silly pairs of headphones we have in the office.

AIR STYLE

This is a set of Corsair's newest HS70 SE Wireless headphones, and we'll be straight-up with you: They're incredible. By far the best wireless headset.... Scrap that—we'll even go so far as to say the best Corsair headset we've ever tested. Aesthetically, they're a breath of fresh air. There's no RGB here, the minimal amount of plastic is soft to the touch, the leather memory foam headband is embroidered in an array of different colors, and the overall feel of them is sturdy. These can take a hit, that's for sure. There's the usual height adjustment on them, but that's it.

It's the audio, though, that carries these beauties: 50mm neodymium dynamic drivers drive both earcups, and although they only come packing a 20Hz–20kHz frequency response, they're some of the most well-balanced coils we've ever seen from the gaming market. Equal even to HyperX's now legendary Cloud series. Everything is crisp, everything is clear, they're not too bass heavy, there's very little distortion, and the mids don't fall flat—it's all very nice. Jump into Corsair's CUE software to access the EQ presets, and you're graced with a grand total of five separate profiles, all of which make quite a dramatic difference to the overall feel of the audio. But, again, nothing here is too harsh, and nothing leads to any distortion. The Bass Boost is our preferred EQ setting, because it pumps up that low end whilst also raising the treble just enough—you end up gaining clarity in the top end whilst securing that fat feel on the bottom. Simply glorious.

So, then, drawbacks? Well, apart from the lack of rotational movement, and no RGB for the, er, enthusiasts, you're still limited to a 16-hour battery life before you need to recharge, and there's no dock or the like. On top of that, the 7.1 virtual surround sound still kind of sucks, even in films and games. It's just too synthetic, and you can tell—but, then, that is an optional extra; you don't have to enable it. Ultimately, for the price, these cans are classy as hell, sound incredible, and are comfortable to boot. It's hard not to love them. –ZAK STOREY

VERDICT **9** KICK ASS!

Corsair HS70 SE Wireless

COLOSSUS Perfectly balanced; awesome price; aesthetically pleasing; good mic.

CRAP The 7.1 virtual surround sound sucks.

$100, www.corsair.com

SPECIFICATIONS

Driver Type	50mm neodymium dynamic
Impedance	32 ohms
Frequency Response	20Hz–20kHz
Microphone Type	Unidirectional noise-canceling
Connectivity	USB
Range	40 feet
Battery Life	16 hours

BattleTech

Hulking heavy metal takes a lesson from *XCOM*

THE MECHWARRIOR GAMES—first-person, real-time explorations of driving a massive walking tank—feel like a long time ago, and *BattleTech* isn't a *MechWarrior* game. It's from the same universe, however, an adaptation of the 1984 board game that started it all, which has come via *XCOM*. You get the feuding interstellar empires and massive walking tanks, but it's all played from above, as a turn-based strategy game.

Following a coup in which a queen is deposed, you find yourself and your mech attached to a mercenary company; you work your passage on its mech carrier to pay off debts and avenge your former ruler. As leader of a lance of up to four mechs, which can be customized and swapped, depending on what you can scavenge or afford, you've got the firepower to make a difference, assuming you can use it right.

The *XCOM* comparisons are many, but a lack of overwatch/opportunity fire seems a glaring omission. In the alien-shooting game, you positioned troopers based on what you thought the enemy might do; here, you can only react to what's already happened. Placing a mech behind a rock becomes a defensive tactic rather than part of a planned surprise attack, but that's not to say there's no strategic depth to be found.

Planning the spread of your mech group, noting the red radar pings that could be enemy mechs or other vehicles, deciding whether to attack with direct fire, indirect fire, a close-up melee blow, or to bow out for the rest of the turn, engaging a sensor lock to make it easier for your teammates to score a hit all requires thought, and plays to the game's turn-based disposition.

But it's slow. We don't mean in the actual action—the mechs skip over the terrain like children—but in getting anything done. You can turn off all action cams, which speeds things up and restores a little sanity after you've heard every bark 10 times over, but doing this doesn't improve the interface.

To be fair, it's doing a lot of heavy lifting. There's a great deal of information to convey, as not only do you have to manage mech position, but also rotation, line of sight, and temperature. Sit in water with a clear line to a target that's rotated the wrong way, and you can blast it off the map easily—just don't expect that situation to arise too often. Get your calculations wrong and the enemy can take out one or more of your mech's 11 hit locations, knocking it over (bad), or killing the pilot (worse).

As a post-*XCOM 2* turn-based strategy game, *BattleTech* was always going to have a lot of work to do to make itself stand out. The giant mechs and their swappable parts are enough of a novelty to be attractive, but the underlying tactics and the way it becomes a game of managing your losses mean that while it's a little raw at the moment, there's a great strategy game here, just waiting to be discovered. –IAN EVENDEN

VERDICT **7**

BattleTech

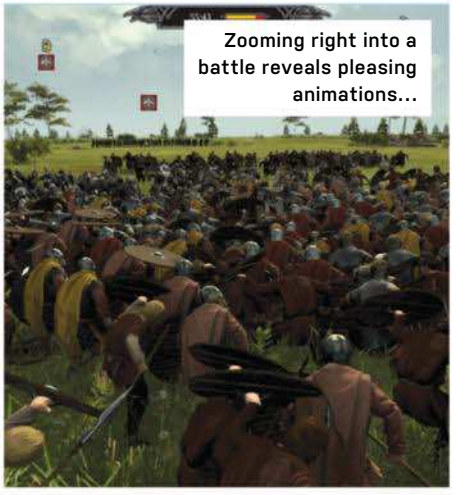
MECH Good range of units; nice range of workable tactics.

BLECH Slow; repetitive; not great looking.

RECOMMENDED SPECS Core i5-4460 or FX-4300; 16GB; GTX 670 or R9 285.

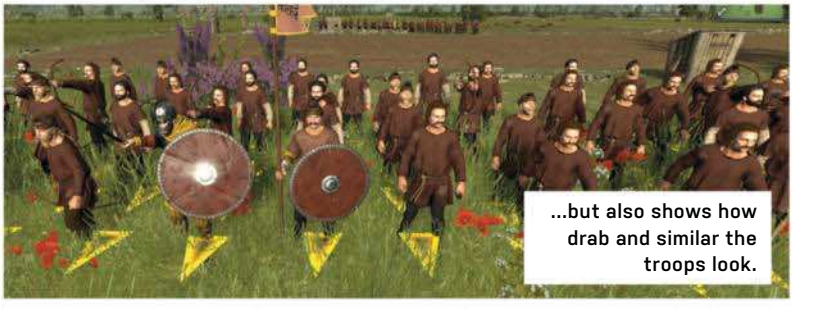
$40, www.battletechgame.com, ESRB: Not rated

Total War's habit of filling the screen with windows still hasn't been tamed.



Zooming right into a battle reveals pleasing animations...

Naval battles are enlivened by mighty Viking longboats.



...but also shows how drab and similar the troops look.

Thrones of Britannia: A Total War Saga

How many kings does a couple of small islands need?

WITH THE WARHAMMER GAMES, Creative Assembly has been making some of the best titles in the *Total War* series, but has also found itself on a punishing release schedule. This year sees two releases, with *Total War: Three Kingdoms* scheduled for the fall, so we wouldn't blame the studio for taking its foot off the gas a bit.

As the first *Total War Saga, Thrones of Britannia* is a stripped-back title focused on a small historical landmass—the British Isles of 878 AD—running on the historical engine that powered 2014's *Atilla*. It's had some polish applied, but is clearly not the particle-fest that's behind the *Warhammer* games. Ultra settings should not be out of reach for most, especially at 1080p, as the relatively mild recommended specs show.

Stripped-back it may be, but there's still a lot of content. Ten playable factions vie for control of small but dense areas, rich with towns to besiege and varied terrain to take advantage of. *Thrones* looks like every other *Total War* game, in that its interface insists on doing its own thing, and it's your job to keep up, but the carved, glasswork-infused style gives it a unique look, authentic to the period. After two years of wizards and Lizardmen, it's almost nice to see the devs getting to grips with history again.

If there's a drawback to the focused setting, it's that everyone on the battlefields of dark age Britain tended to be bearded, wear brown, and carry a shield along with something sharp. Careful use of the army management tools is required to avoid leaving a unit of archers standing around doing nothing because you thought they were on the other side. A major change is in the way armies are mustered, with units joining your forces at low strength, then gradually becoming stronger until they're ready to be deployed. It adds an extra layer of planning to the strategic map game, as going into the real-time battles with an under-strength force is a path to defeat.

Victory can come in several ways: by achieving objectives, such as conquering a number of provinces, or by not achieving anything much but becoming famous. You can be handed a victory if the powerful king of another faction dies after naming you as his heir, without having to face him in battle, or you can play the long game for an "ultimate" victory that sees you face off against everything the game has to offer.

The pared-down nature of this *Saga* has given *Total War* a new lease of life. The small map allows the devs to really drill into the detail of the period, while the cutting of skill trees and agents/heroes has taken some of the baffling complexity out of the huge number of windows it's possible to open. In a genre where more is most definitely more, sometimes a little less can go a long way. **–IAN EVENDEN**

VERDICT 8

Thrones of Britannia: A Total War Saga

BRITISH Honed, focused campaign; changes are improvements.

SKITTISH Troops a little samey; some victories relatively easy.

RECOMMENDED SPECS 3.2GHz i5-4570; 8GB; GTX 770 4GB or Radeon R9 290X 4GB.

$40, www.totalwar.com, ESRB: Teen

LAB NOTES

ALAN DEXTER, EXECUTIVE EDITOR

Saying Goodbye to a Classic

Another machine gets a new home

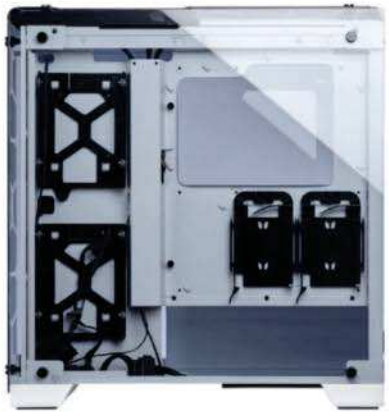
LAST MONTH, I swapped the chassis (and a few other components) of my main work machine, and this month I've done the same to my home system. The aging Cooler Master Cosmos that housed the last two iterations of my home PC served me well, but it was getting a little long in the tooth in terms of looks, and was too big for what I needed. I wanted something smarter, more modern looking, and frankly something smaller.

The Corsair Crystal 570X is a mid-tower case, so it checks the downsizing box nicely, and it's also very smart and modern looking. Prior to using it, I wasn't sure about the RGB fans, but they're not as garish as I feared, especially after cycling through the presets to find a subtle purple glow. The triple fans do a great job of keeping the rig cool, too.

Making the move wasn't without its problems, with the 12V ATX CPU cable in the old Cosmos stretching across the motherboard and under the graphics card to reach the slot. Despite the slighter small proportions of the new case, it was a tough fit here as well, although I did manage to route the cable around the back of the mobo and hook it around the top. It's not very pretty if you look at the rear of the machine, but without buying a new power supply, there's not much else I could do.

The cabling for the drives was frustrating, too, with the initial setup refusing to spot the OS drive because the SATA power cable had slipped out of the drive. It's annoying that the data cables use spring clips, while the power cables don't. Once I'd sorted out the cabling properly, this was less of a problem, but I'd still prefer clip-in cables.

One offshoot of the move is that there's no room for an optical drive now. To be fair, while the drive was in the old Cosmos, I hadn't hooked it up to the mobo in the last build, so it clearly wasn't an essential part of my computing regime. But it may come in useful one day, so instead of heading to the recycling center with the Cosmos, it's made its way into the tech purgatory in the attic for now. You know, just in case....



Nowhere to hide your mess in this case.

BO MOORE
Hardware Lead

I'm tired of choosing between G-Sync and Optimus. If you don't know what I'm talking about, Optimus is a piece of Nvidia technology that enables laptops to default back to the integrated Intel GPU when you aren't playing a game. With the dedicated GPU not in use all the time, your power draw is significantly lower, and thus your battery lasts a lot longer. G-Sync, on the other hand, is Nvidia's variable refresh rate technology. And you'll never find the two of them together on the same laptop.

Of course, there may be valid technical reasons why the two don't play nice with each other, but it really sucks having to choose between a variable refresh rate and long battery life on gaming laptops. I absolutely love the new slate of thin and light Max-Q laptops. They're sleek, powerful, and have fantastic battery life, but it's absolutely crazy that they're lacking in that silky smooth, tear-free experience—especially because they're increasingly outfitted with high refresh rate screens. Yes, I know we're all excited about next-generation GPUs, but I'm just saying that Nvidia should dedicate some of its resources to working this little squabble out. I mean, Optimus and G-Sync are both Nvidia technologies. They're basically siblings. The time has come for a family reunion. Make it happen, Nvidia!

Editors' Picks:
Digital Discoveries

Zak Storey, deputy editor, and Jarred Walton, senior editor, share their latest tech treats

MY FITNESS PAL

With mountain biking, fitness is king. The stronger you are, and the more you ride, the faster you go. In preparation for races, I gym-train five times a week for six to eight months a year, and go riding once or twice on the weekend.

Training, however, is just one part of the equation. Nutrition is equally as important to overall performance, and you'll see far bigger gains if you eat right than if you don't.

When it comes to calorie tracking, My Fitness Pal is my app of choice. Sponsored by Under Armour, it's possibly the most useful app in my life. A free account nets you access to your own food diary, which includes a barcode scanner with a repository of nutritional information on over five million food items across the planet, from Arby's to Trader Joe's. You get weight tracking, too, and a ton of articles devoted to fitness.

Personally, I cough up for the Premium subscription ($50 for the year), because I'm a sucker for detailed information. Apart from it being free from ads, it gives me a breakdown of my calorie intake by meal, nutrient analysis (protein, carbs, fats, cholesterol, and more), and a ton of other analytical tools. Either way, if you're serious about fitness, it's worth taking a look.

$Free, www.myfitnesspal.com

LOGITECH BRIO

Want to be the next Twitch sensation? If so, you need a good webcam, and Logitech is often the best option, regardless of price range. From the 4K-capable Brio down to the affordable C920, you can get the software and camera you need. My pick is the top-of-the-line Brio, a 4K30-capable webcam to capture all the details you need—and some you don't.

Personally, the bandwidth requirements of 4K are too high for my connection, at least for real-time streaming. Besides, if you're Twitch streaming, you're normally just a small torso in the corner of the screen. But the Brio offers more than just 4K—it has 1080p60 support. After seeing 60fps videos recorded with the Brio, 30fps streams just look janky. You might not need the ultra-high resolution, but frames per second matter.

Logitech's Brio doesn't have Intel's RealSense tech, which can be useful for removing the background from your streams and videos, but it does include a faux green screen capability that works OK. And the Brio isn't just about gaming and streaming. If you've ever noticed the poor video quality from your laptop's built-in webcam, the Brio (or even the C920) is an excellent upgrade for Skype and other business solutions.

$180, www.logitech.com

GEEK TESTED & APPROVED

Q Acoustics M3 Soundbar

IT'S NOT EVERY DAY we get to look at a soundbar here at *Maximum PC*. But when the boys who look after Audio Technica's PR pitch a noise-producing product at your ass, you tend to sit up and listen. I was a little taken aback at first—after all, we know our audio, sure, but home hi-fi? That's a whole different kettle of fish from what we usually review within these hallowed pages.

That said, it's not something I haven't thought about looking at before. Hell, it's not even as though we haven't already seen these in the industry—Razer's Leviathan is a prime example of that.

Q Acoustics' Q3 soundbar is on the table for us to review this issue, and we have to be honest, it's pretty good. But it ought to be for the price—at a sweet $250, it's hardly a cheap affair. It's direct and punchy, connects easily enough to Bluetooth, and has what we would consider a well-pronounced soundstage, if somewhat bass-heavy, due to the integrated subwoofer.

It's a little trickier when connecting it to your rig, however, because you need an optical audio or TOSLINK cable to connect it and get it to work. We did try to be sneaky and plug it in via HDMI straight into the GPU (because Nvidia drivers do include high-definition audio-out via HDMI), but try as we might, we just couldn't produce audio out of the well-designed device.

All in all, it's a well-balanced soundbar, perfect for a home theater, but a little cumbersome for a rig **–ZS**

$250, www.qacoustics.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Core Confusion
> Building Bonus
> Simple Guides

All About Performance

I must be going a little silly as I get old. I could have sworn that my old Core i7-950 Nehalem architecture was a quad-core. I honestly didn't know it was an early single-core legacy processor. I also didn't know that most games from six or seven years ago needed two to four high-powered cores to get the job done, but single-core was the king! Let's see: It seemed like we had quad-cores, but most games couldn't take advantage of those extra cores, due to not being encoded for the extra cores. Honest, I am so confused now that I think everything I've read in *Maximum PC* for several years must be a lie, and I've learned nothing by being a long-time subscriber. Maybe should get my info from another source.... **–Rick Ulbrich**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: The article in question, "Optimize Your Upgrades," was actually pointing out that the single-core performance that Intel enjoys today can be traced back to architecture used by that venerable chip, not that it only had one core. We haven't had serious single-core processors on desktops since the Pentium 4, and even that had Hyper-Threading. Since the original Nehalem, Intel has refined and tweaked this architecture, but its DNA hasn't shifted significantly.

As for gaming, developers are bound by the install base to only make the best out of what most people have, not what's necessarily available—we may have 16- and 18-core processors available, but no developer is going to produce a game that is optimized for such a chip, as the vast majority of gamers still only have quad-core chips at best (according to the most recent Steam survey, over 90 percent of the market has quad-core or less, with 30 percent still rumbling along with dual-core silicon). Don't worry, we haven't been lying to you, just trying to keep you on your toes.

Bottleneck Business

Thank you for the article on bottlenecks. I downloaded the two programs that you had recommended (HWMonitor and Unigine Superposition), and discovered what the bottlenecks were in my system. The results were no surprise, as my machine is almost six years old, but has been upgraded over the years probably as far as one can. However, it was interesting to see how well a system as old as mine was performing. I can play *CoD WWII* at 40fps, so I'm happy. I've attached a screengrab of my GPU benchmark results to this email. **–Scott Cortese**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Glad to hear you found the article enjoyable and useful, and that you can play the game you want at smooth frame rates. This is one of the reasons we love PCs so much—you can keep upgrading them to get a machine that is still relevant years after its creation.

Do You Vape?

What's with the vaporware you guys keep reviewing? I was looking for an ITX board for my Ryzen 5 processor. You reviewed the Asus ROG Strix X370-I Gaming. Nope, nobody has it. Then you reviewed the MSI B350i AC. Again, nowhere to be found. Can I get one of the boards you reviewed? They seem to be the only ones in existence. Can you guys tell manufacturers to confirm they are actually going to sell the boards they send you before you put out a review? **–Joey Martinez**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We have no interest in reviewing vaporware, but that isn't what's happening here, as the products in question do exist, they just appear to be rather popular, and as such, have sold out at a lot of places. Even so, at the time of checking, a look at the "Where to buy" section of the official Asus US website shows that B&H has stock (while Micro Center and Walmart have sold out). As for the MSI motherboard, it does indeed appear to have sold out everywhere—even the "Where to buy" links all point to a lack of stock (at least, the several we tried did). Even so, when we get hardware in for review, we always make sure that it is available to buy, otherwise there wouldn't be any point looking at it. Of course, what we don't know is how many of a particular motherboard are made available to the

↘ submit your questions to: comments@maximumpc.com

market, or what the take-up will be.

Buyer Beware

I thoroughly enjoyed the "Builder's Bible" article in your April issue, especially the prep work that needs to go into a build, which I haven't seen in similar articles. There are two things I want to comment on, though. (1) Regarding your suggestion about buying one or two pieces of hardware per month, instead of going all-out in one go—buyers need to be aware of the vendor's return policy. You don't want to run into a situation where you buy items over a multi-month period, and then six or seven months later, for example, go to build the system only to find that a piece of hardware is defective or dead, and you can't return it, because it's way past the vendor's return policy time frame. (2) I worked part-time on a "Build Your Own Personal Computer" course at a community college (first as a volunteer lab assistant, and then a co-instructor) for a number of years. The students purchased the parts to build a computer, and myself and other lab assistants and the two instructors would assist them. There was more than one occasion when a student purchased a new, well-known brand-name part from a reputable vendor, only to find out that it was DOA when we went to fire up the system. Usually it was memory, but we had a couple of motherboards that were also DOA.

Instead of installing everything in the chassis before the system is fired up, we would place the motherboard on a piece of plywood large enough to accommodate a full-size ATX motherboard, and install the CPU, cooler, and memory. Then, we'd connect a PSU, ATX power switch, video card (if needed), monitor, keyboard, and system speaker (if needed) to the motherboard, and fire it up.

Sometimes, when a system wouldn't go through POST, reseating the RAM or CPU, or resetting the BIOS took care of the problem. However, as I previously mentioned, there were also a few occasions when a part was DOA. Yes, I know things are not properly grounded this way, as they would be in a chassis, but we ran the system only long enough to make sure that the BIOS properly recognized the CPU and memory, and that the CPU temp did not increase drastically and beyond acceptable limits. Not all students purchased chassis with lots of working room inside. It's easier to reseat a CPU, RAM, or cooler outside of the chassis than it is inside of one. This is true especially if the power and data cables have also been connected to all of the components.

–Michael Craddock

[NOW ONLINE]

THE BEST GRAPHICS CARDS

When it comes time to build or upgrade your new gaming PC, deciding on the best graphics card is a big consideration—it's the component that demands the biggest chunk of your budget. Sure, you'll want a decent processor and enough RAM and storage, but the GPU is the beating heart that pushes pixels on to your display.

Graphics cards consist of a dedicated graphics processor (GPU) coupled with high-speed video memory (VRAM). Most modern cards have at least 3–4GB VRAM, with high-end models including 8GB or more. Having enough memory is important, as is memory bandwidth, with GDDR5 cards typically providing over 100GB/s to keep your GPU fed.

Read the full article at https://bit.ly/2vB6zSH

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Cheers for your feedback, and your own personal tips for system building. Your first point is valid, and it's worth bearing in mind—although don't forget that you can return components to the manufacturer even if you're outside of the reseller's warranty. As for the second point: We have different preferences on the team, and some of us (including myself) always build outside the case first, to ensure the core components work, while others are happy to save any nasty surprises until further down the line.

A Call for Simplicity

I am a fan of your magazine, even though I have no idea of what you're talking about more than half the time. Yes, that sounds crazy, but I enjoy reading about the computer/IT technology, and you and your staff do an excellent job of presenting that information. However, I must ask: Is there a publication for those like me who wish to read to be acquainted with computers, but on the most elementary level, so we too can become advanced consumers, like the ones your magazine is geared toward?

This would be my dream machine for gaming and productivity combined:
Case Cheapest full tower available.
Motherboard X99.
CPU The lowest cost, able to take advantage of the motherboard's capabilities.
Memory Cheapest, minimum, with all slots occupied.
GPU One board, but if needed, two (see CPU).
Storage Three SSDs.
1. OS dedicated, with enough room to accomplish update functions
2. Productivity software, such as Microsoft Office.
3. Entertainment, partition for games, music, and so on.
Data storage HDD—4x 500GB, or 2x 1TB. Is this too much or too little?
Cooling Lowest-cost CPU water cooler.
PSU Minimum needed for the build, plus the necessary percentage over.
OS Microsoft Windows 10.

What would be the cost of this system, at minimum?

Note: I have two older motherboards (EVGA nForce 680i LT SLI) and another one, that I have been trying to restore, so I can understand how to configure the system the way I want it, see above; no progress. **–Willie Gary**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We've got an in-depth, blow-by-blow build planned for later in the year that should be right up your street. As for your particular build, we're a bit confused why you've specced up an expensive yet out-of-date motherboard (most high-end builds have moved to X299/AMD X399), but we'll cover all of this in the forthcoming feature.

MAXIMUM PC DIGITAL EDITION

ANYTIME, ANYWHERE!

AS LITTLE AS $1.99 PER ISSUE!
MAXIMUMPC
SPEED UP WINDOWS
Make your machine run like new again
Solve all of your OS problems
Clean out the junk for faster booting
VIDEO ENCODING 101
STEP-BY-STEP GUIDE

Delivery of **MAXIMUM PC**, in your choice of
Apple Newsstand, Google Play, or Zinio

From only $1.99 a month

Search for **MAXIMUM PC**
on your device's app store to download now

Available on the App Store

GET THE MAGAZINE ON Google play

zinio™

THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$91
PSU	450W Corsair CX450	$40
Mobo	ASRock AB320M-HDV NEW	$50
CPU	AMD Ryzen 5 2400G	$160
GPU	N/A	$0
RAM	8GB (2x 4GB) Team DDR4 @ 3200MT/s NEW	$94
SSD	120GB Adata Ultimate SU650 2.5-inch SSD	$34
HDD	Hitachi Deskstar E7K1000 1TB 7,200rpm	$37
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$16

Approximate Price: $522

IT WAS ALL GOING SO WELL. GPU prices have fallen, the rising tide of memory cost has receded, yet our budget build has still increased in price. Why? The case. The Nova TG, our budget ATX chassis of choice, is seemingly at its end of life, meaning less availability and a bumped-up price. We've tried to compensate by dropping to a lower-spec board (only capable of supporting 65W TDP CPUs, so bear that in mind when thinking about future upgrades). That aside, this is still a solid, well-balanced entry-level rig. You get the full might of those Vega GPU cores inside a pretty impressive quad-core chip, 8GB of DDR4 for all your mid-range gaming and office needs, and a healthy 1TB of storage. Just make sure when you pick up the mobo, you get the one that's Ryzen 2000 ready and with the DVI-I port on the rear I/O, as ASRock has multiple AB320M boards. And don't worry about the chassis, we'll change that next issue.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$80
PSU	550W EVGA SuperNOVA 550 G3 80+ Gold NEW	$80
Mobo	MSI Z370 Tomahawk	$120
CPU	Intel Core i5-8400	$180
Cooler	Be Quiet! Dark Rock 4 NEW	$75
GPU	EVGA GeForce GTX 1060 3GB Gaming ACX 3.0 NEW	$240
RAM	16GB (2x 8GB) Patriot Viper Elite DDR4-2400	$155
SSD	250GB Samsung 970 Evo M.2 PCIe SSD	$108
HDD	Hitachi Deskstar E7K1000 1TB 7,200rpm	$37
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,175

MORE SAVINGS THIS ISSUE with our mid-range build. We've opted for a swanky EVGA power supply this time around, still 550W, still 80+ Gold, and still fully modular, but it's a nice additional saving over the Corsair one from last issue. We've also opted to bump up the models of both our CPU cooler and GPU, going from the Dark Rock Pro 3 to the newly released Dark Rock Pro 4 (at the same price), and from the GTX 1060 ACX 2.0 to the ACX 3.0. Newer designs, better cooling, and ultimately better support. Combine all that with our Intel Core i5-8400, and this machine really does start churning out the numbers in the mid-range bracket, perfect for some high-end AAA 1080p gaming. That said, with the advent of the latest Ryzen 5 2600 coming in at only $10 more, for very similar single-core performance and an even greater multicore hit, it might be time for us to ditch the Core i5-8400 altogether, but more on that later.

UPGRADE OF THE MONTH

AMD RYZEN 5 2600

The Ryzen 5 2600—hot damn, what a chip. This thing is truly king of mid-range processors right now, especially as far as a value proposition is concerned. Let's compare it to the Core i5-8400 in our mid-range build. Cinebench R15 Single-Core: Intel 165; AMD 159—4 percent difference. Multicore? Intel 945; AMD 1,274—35 percent difference. Hell, that's a substantial win on the multicore, and for the sake of 4 percent in single-core, a sacrifice we're willing to make, especially for $10 more. But there's one caveat that extends AMD's lead substantially: overclocking. Bump up those ratios, and you'll see both single and multicore performance demolish the Core i5 by 8 and 51 percent respectively. If AMD keeps up this level of improvement, and Intel doesn't reinvigorate itself, the PC community in a year or two's time is going to look very different.

$190, www.amd.com

SO, WE'VE INCREASED THE CORE COUNT from 12 to 16, bumped up the size of the radiator AIO by 50 percent, and managed to save $170 in the process, even with an increase in the price of memory. And who do we have to thank? Samsung. Yup, the price of Samsung's 512GB 970 Pro drive has come crashing down by an impressive $142 since last issue. Staggering. Combine that with the continual plummeting prices of GPUs and some motherboard frippery, and what you're left with is ample room to increase those specs rather dramatically.

Boy, are we glad those ASIC miners came out when they did. So, this is a full-fat machine now, rip-roaring, and ready to kick Maximum ass. Unfortunately, Computex didn't reveal much to us this time; there's an abundance of new cases, but as far as major platform releases are concerned, very little was confirmed. We know AMD's launching a 32-core part at some point, and we know Intel has its funky 28-core thing, but those will be well beyond the price range of our Turbo build, unless the pricing side of things falls dramatically. There's also been very little mention from either Nvidia or AMD with regard to a new series of GPUs, meaning what we're left with is a somewhat mature market, and a very mature build that should last for quite some time.

If we're honest, and you're eyeing up this build, your best bet may be to wait until the end of autumn to see how Intel and AMD compete against one another in their next-gen CPU wars.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

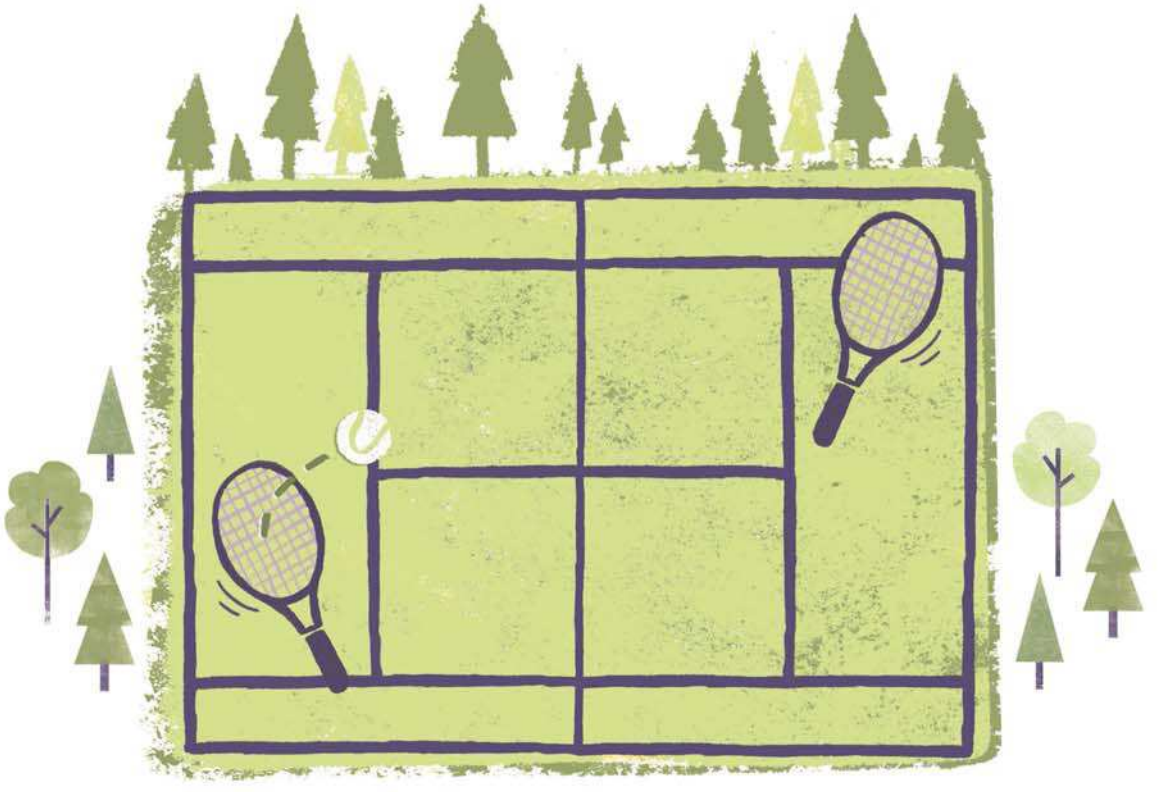
INGREDIENTS

PART		PRICE
Case	NZXT H700i	$200
PSU	Corsair RM750X Modular Gold	$110
Mobo	ASRock X399 Taichi	$319
CPU	AMD Ryzen Threadripper 1950X NEW	$750
Cooler	NZXT Kraken X72 NEW	$200
GPU	Gigabyte GeForce GTX 1080 Ti Turbo 11GB	$720
RAM	32GB (4x 8GB) G.Skill TridentZ Series - 3200 MT/s NEW	$388
SSD	512GB Samsung 970 Pro M.2 NVMe	$228
HDD	2x 2TB Seagate BarraCuda ST2000DM006	$118
OS	Windows 10 Home 64-bit OEM	$100
Approximate Price:		**$3,133**

Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus a Spring issue following the March issue, by Future US, Inc., 11 Hanover Square, 14th Floor, New York, NY 10005, USA. Website: www.futureus.com. Periodicals postage paid in San Bruno, CA, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: $24; Canada: US$40; Foreign: US$40. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to *Maximum PC*, PO Box 5852, Harlan, IA 51593-1352. Standard Mail enclosure in the following editions: None. Ride-Along enclosure in the following editions: None. Returns: IMEX Global Solutions, PO Box 25542, London, ON N6C 6B2, Canada. Future US, Inc. also publishes *@Gamer*, *MacLife*, *The Official Xbox Magazine*, and *PC Gamer*. Entire contents copyright 2018, Future US, Inc. All rights reserved. Reproduction in whole or in part is prohibited. Future US, Inc. is not affiliated with the companies or products covered in *Maximum PC*. Reproduction on the Internet of the articles and pictures in this magazine is illegal without the prior written consent of *Maximum PC*. Products named in the pages of *Maximum PC* are trademarks of their respective companies. PRODUCED IN THE UNITED STATES OF AMERICA.

22 THOUSAND

TENNIS COURTS EVERY DAY!



Did you know that U.S. forests, which provide wood for making paper and many other products, have been growing every day, equal in area to more than 22,000 tennis courts!

Love magazines? You'll love them even more knowing they're made from natural, renewable and recyclable wood.

UNFAO, Global Forest Resources Assessment 2005-2015

Two Sides is a global initiative promoting the responsible use of print and paper which, when sourced from certified or sustainably managed forests, is a uniquely powerful and natural communications medium.

Discover more great #PaperFacts at **twosidesna.org**

TWO SIDES

We build the world's most advanced PCs.

Experience a new level of performance with an award-winning Digital Storm PC. Built with the latest technology, highest quality components and backed by lifetime support. Visit our website and build your dream PC today.

DIGITALSTORM

LEARN MORE: WWW.DIGITALSTORM.COM

Digital Storm PCs featuring Intel® Core™ i7 processors.

intel CORE i7 inside

The Digital Storm Logo, and 'World's Most Advanced PCs' are trademarks of Digital Storm. Intel, the Intel Logo, Intel Inside, Intel Core, and Core Inside are trademarks of Intel Corporation in the U.S. and/or other countries.